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IDENTIFICATION OF THE POTENTIAL CHARACTERISTICS, APTITUDES, AND ACQUIRED SKILLS INVOLVED IN HUMAN DETECTION OF MINES

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13. ABSTRACT

This report summarizes findings from three research tasks comprising Project IDENTIFY. In the first phase, a job model for human mine detection was developed, a psychological analysis of the mine and boobytrap detection process was conducted, and literature on the individual differences involved in visual discrimination was reviewed. From the information developed, 24 individual different variables were identified as potential predictors of mine and boobytrap detection performance. In the second phase, predictor measures for mine and boobytrap detection were developed and validated. The results of the validation showed that mine and boobytrap detection was primarily dependent upon search speed and the effort that appeared to be expended during search. Also, detection rates and distances were computed for each type of mine employed during the validation. In the third phase, personnel selection and training methods for mine and boobytrap detection were identified and recommended.

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Identification of the Potential Characteristics, Aptitudes, and Acquired Skills Involved in Human Detection of Mines

by

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SUMMARY

This report presents the results of research accomplished on the three research tasks comprising Project IDENTIFY, Identification of the Individual Differences Involved in Human Mine Detection. Specifically, the report discusses the research accomplished on *Task A*, Identification of the Potential Characteristics, Aptitudes, and Acquired Skills Involved in the Human Detection of Mines; on *Task B*, Validation of the Potential Characteristics, Aptitudes, and Acquired Skills Involved in the Human Detection of Mines; and on *Task C*, Identification of Appropriate Selection and Training Methods for Human Mine and Boobytrap Detection.

The *Task A* research was conducted in three phases: (a) development of a job model for the mine and boobytrap detection job, (b) performance of a psychological analysis of the processes involved in the mine and boobytrap detection, and (c) review of the psychological literature with respect to individual differences involved in visual discrimination.

The work performed during these three phases led to the identification of 24 specific characteristics, aptitudes, acquired knowledges, and acquired skills as potentially predictive of human mine detection performance.

The *Task B* research was conducted in two phases: (a) development of predictor measures for mines and boobytrap detection performance, and (b) validation of the developed predictor measures. It was determined that 17 of the 24 individual difference variables identified during *Task A* were amenable to practical assessment. Ten paper-and-pencil tests and one performance test were identified to measure 14 of these variables. Since it was judged that the remaining three individual difference variables would be best measured under field detection conditions, appropriate measurement procedures were developed.

The paper-and-pencil tests and the performance test were organized into a test battery that was administered to 111 male enlisted personnel stationed at Fort Benning, Georgia. After completing the test battery, these men were tested for antipersonnel mine and boobytrap detection proficiency in a wooded environment. During this test, speed of movement during search, effort expended during search, and search technique were assessed. The antitank mine detection proficiency of these men was evaluated in an open country area and also in a road environment.

The results of the validation indicated that the most effective prediction of mine and boobytrap detection performance occurred when the prediction equation included speed of movement during search, the effort that appeared to be expended during search, visual acuity, level of activities participation, number of years of civilian education, means by which a high school diploma was earned (by graduation or completion of the tests of General Educational Development), and level of dogmatism. Also, detection rates and distances were computed for each type of antipersonnel and antitank mine employed during the validation.

Finally, the *Task C* research was conducted in two concurrent phases: (a) development of recommended selection methods, and (b) development of recommended training methods. This task was accomplished through review of the results of the validation and relevant military documents. It was recommended that personnel selection for mine and boobytrap training be based on the results of a screening procedure and the completion of a test battery measuring the variables found to be predictive of detection proficiency in the validation study. The recommended training for mine and boobytrap detection addressed the following topics: speed of movement during search, effort expended during search, search procedures and basic detection cues. Recommendations concerning the conduct of this training were also made.

FOREWORD

This report presents the results of research conducted to identify and validate a set of individual difference variables predictive of human performance in mine detection. In addition, it discusses personnel selection and training methods for human mine and boobytrap detection identified by the staff of Project IDENTIFY from assessment of the results of the validation.

This research was funded under Contract DAAK02-73-C-0116, Project No. 3A460059, U.S. Army Mobility Equipment Research and Development Center (USAMERDC), Fort Belvoir, Virginia. The purpose of the research was to provide support for the USAMERDC Human Mine Detector Research Program by developing quantitative data for input to countermine system/subsystem analyses and identifying/validating specific design parameters that are likely to be predictive of mine and boobytrap detection performance under combat conditions.

The research was performed by Mr. Jeffery L. Maxey, Mr. Theodore R. Powers, and Mr. George J. Magner under the direction of the Principal Investigator, Dr. T.O. Jacobs, Director, HumRRO Division No. 4, Fort Benning, Georgia. Military support consisting of 2LT Thomas Fitzgerald, SFC Cornell Smith, PSG Lathaniel Henderson, SP5 Rodger Griffeth, SP5 James Tripp, SP5 Ralph Hammond, SP4 Ennis Brooks, SP4 Carl Cordova, SP4 Raymond Singleton, SP4 Lonsworth Smith, PFC Doretha Heyward, and PFC Ronald Keen was provided by the U.S. Army Infantry Research Unit which is commanded by LTC Willys E. Davis.

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Identification of the Potential Characteristics, Aptitudes, and Acquired Skills Involved in Human Detection of Mines

INTRODUCTION

Antipersonnel mines, antitank mines, and boobytraps are weapons which conventional and insurgent forces employ to inflict casualties, to reduce the individual soldier's capacity to respond to other threats, and to limit a unit's method and flexibility of operation during combat operations. Since it is likely that these devices will be used on future battlefields, a need exists to identify individual parameters that predict the acquisition of the unaided/unassisted human skills required for detection of land mines and boobytraps. The identification and validation of these parameters were the primary purposes of the present project.

The overall project was divided into three tasks: (a) identification of the potential characteristics, aptitudes, and acquired skills involved in the human detection of mines, (b) validation of the identified characteristics, aptitudes, and acquired skills, and (c) identification of appropriate selection and training methods for human mine detection. This report presents the findings that resulted from the accomplishment of these tasks. It is expected that information provided by this project will be used to:

(1) Develop selection procedures for improving the input to visual detection training programs.

(2) Developing training and testing procedures that will improve mine and boobytrap detection performance.

(3) Define system parameters that can be used as input to countermine systems definition analyses currently underway at the U.S. Army Mobility Equipment Research and Development Center (USAMERDC).

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Chapter 1

IDENTIFICATION OF CANDIDATE PREDICTOR VARIABLES

BACKGROUND

Usually, the detection of objects or figures is studied in terms of the various environmental (target and background) variables which separately or in various combinations yield increments or decrements in the performance of human observers. Observer responses are usually examined collectively in order to study the effects of various treatment conditions on performance. Individual differences are regarded as sources of error. In fact, it is often the case that only well practiced or highly proficient observers are used in detection research, so that between-observer differences will be at a minimum. Thus, in most work on detection problems, variability among observers has been viewed as a problem to be eliminated, because it obscures differences among various target and environmental treatment conditions.

However, some problems require a focus on individual differences. Selection for high performance aptitude is an example. Generally, a population is surveyed on a relevant test or tests, and high scorers are then given training on the skill in question. The assumption is that individual aptitude differences exist, and that training will be more efficient and effective if individuals with high aptitude are identified and selected for that training. The problem of training for visual detection of mines and boobytraps is assumed to fit this model. The assumption is that if high performance aptitude exists and can be predicted, then mine and boobytrap training can be both more efficient and more effective.

Mines and boobytraps can strongly affect the outcome of a military operation, both by causing casualties among personnel and by impeding operations. For example, data collected by Magner[1] in Vietnam during February 1968 indicated that approximately 33% of the 1967 Vietnam casualties sustained in the units studied were from contact with mines and boobytraps. In a recent study conducted by the Picatinny Arsenal,[2] involving 21 tank crews, it was found that surface-laid antitank mines emplaced as a barrier to movement resulted in sufficient delay in two military operations to enable antitank weapons to be brought to bear on the assaulting force. These findings suggest that a need exists to develop an easily applied, reliable, and effective means to detect mines and boobytraps hidden or camouflaged in field environments.

One possible solution to this problem is to improve through training the visual detection performance of the observer who is responsible for detecting mines and boobytraps. Another possible solution is to give military personnel who have high performance aptitude the responsibility of detecting mines and boobytraps.

Prior research to identify individual differences predictive of human mine detection performance has been conducted by both the Picatinny Arsenal and HumRRO Division

[1]Magner, G.J. *Detection and Avoidance of Mines and Boobytraps in South Vietnam*, HumRRO Consulting Report, June 1968.

[2]Bucklin, B., *et al. Camp Drum Test of Mine Effectiveness*, Technical Memorandum 2067, Picatinny Arsenal, Dover, New Jersey, December 1972.

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No. 4. Carlock and Bucklin[3] report that some individuals are very adept at finding camouflaged, partly hidden, or concealed objects, while others are not. Their work has indicated that the skill is consistent—if an individual is good at detecting one type of object, he is usually good at detecting other types. Most of their work has involved the detection of surface-laid munitions of various colors, sizes, and shapes in field detection situations, using enlisted personnel as subjects.

In addition to establishing that the detection of surface-laid objects is a reliable individual skill, the Picatinny researchers have found that actual detection rate (number of objects detected divided by the total number available for detection) is significantly but only moderately correlated with Army General Classification Test (AGCT)[4] performance (a general ability measure), Hidden Figures Test (HFT) performance (a measure of ability to find embedded figures), time spent searching, and the personality dimensions of reflection action and perseverance. However, on the negative side, they have found that a wide variety of other perceptual (both performance and paper-and-pencil), personality, and background measures were not significantly related to detection performance.[5,6]

Maxey and Magner[7] have also studied individual differences in the detection of mines and boobytraps. They interviewed and tested 78 enlisted and officer personnel who were identified as either "expert" or "non-expert" mine and boobytrap detectors. In this analysis, expertness was estimated by a linear combination of general military knowledge and combat experience data (collected during the interviews) considered relevant to detection performance by military experts.

Data were gathered on 21 individual difference variables. Analysis revealed that only two variables—Ability to Use Concepts and Ability to Visualize Spatial Relationships—were significantly correlated with detection expertise. However, these relationships were only moderate. Further, the relationships between the remaining 19 variables (which included general and embedded figures ability measures) and detection expertise were all nonsignificant.

It is clear from these results that few individual difference variables have been demonstrated to be clearly and significantly related to human mine detection expertise. This suggests either that human mine detection performance is essentially an unidimensional ability that is related to only a small number of specific individual parameters or that the correct variables have not been selected for study in the research to date. The major purpose of the *Task A* research was to investigate this question further.

APPROACH TO THE *TASK A* PROBLEM

The goal of the *Task A* research was to identify the potential characteristics, aptitudes, and acquired skills involved in the detection of mines and boobytraps. This phase of the work was accomplished in three steps. First, a job model was developed that

[3] Carlock, J. and Bucklin, B. "Human Factors in Mine Warfare: An Overview of Visual Detection and Stress," paper prepared for presentation at the TTCP Panel 0-1 Working Group 5, Mine Warfare Study Group Seminar, October 1971.

[4] AGCT has been supplanted by the Armed Forces Qualification Test (AFQT) and the Army Classification Battery (ACB). The scores used here are almost certainly General Technical (GT) scores derived from the ACB.

[5] Bucklin, B. *Field Dependence and Visual Detection Ability*, Technical Report 4137, Picatinny Arsenal, Dover, New Jersey, May 1971.

[6] Bucklin, B. Personal communication, January 1973.

[7] Maxey, J.L. and Magner, G.J. *A Study of Factors Affecting Mine and Boobytrap Detection: Subject Variables and Operational Considerations*, HumRRO Technical Report 73-12, June 1973.

identified the inputs to the personnel who perform the detection job and the outputs they make back into the infantry combat system; second, a psychological analysis was made of the mine and boobytrap detection task in order to determine the specific human cognitive and perceptual aptitudes that are likely to be involved; and third, a review of the psychological literature was performed to identify individual differences that have been shown to be related to visual discrimination.

The Job Model. The detection of mines and boobytraps is generally accomplished within the Light Weapons Infantryman System. The basic components of this system are:

(1) Mission
(2) Organization
(3) Operational Techniques and Tactics
(4) Equipment
(5) Personnel

Each of these components was systematically studied to determine the effects they have on the mine and boobytrap detection job.

The study of this system began with a review of the relevant mine and boobytrap detection literature. It was updated through discussions with personnel who presently conduct training in this area and through on-site observation of U.S. Army Infantry School instruction on this topic.

Next, the model was developed through analysis of each of the inputs to detector personnel from the various components of the system and through identification of the outputs back into the system required of the detector. The result of this step was a model that specifies the parameters of the detection job and the tasks required for successful completion of this job.

The Psychological Analysis. Using the detection job model as a guideline, a psychological analysis of the detection process was performed. This analysis was based on a survey of theoretical psychological literature that addressed the processes underlying the detection of objects in their natural surroundings. The result was the identification of a set of cognitive and perceptual aptitudes that are basic to the accomplishment of any field detection task.

The Visual Discrimination Literature Review. The review of the visual discrimination literature was limited to the psychological research conducted within the last ten years (1962-1972) and only that which involved normal human subjects. A given study was included only if the effect of some individual difference variable (or variables) was assessed and then only if the perceptual task involved some form of visual discrimination. From this review it was possible to identify a set of specific individual difference variables that have been found to be significantly related to visual perception.

RESULTS

The Job Model Inputs

The countermine mission of friendly forces is to detect, avoid, and (possibly) neutralize enemy mines and boobytraps. Mines are defined as explosives or other materials that are normally encased and are designed to destroy or damage vehicles (antivehicular mines) or personnel (antipersonnel mines). These devices may be detonated through the action of the victim, by the passage of time, or by controlled means. Boobytraps are defined as explosive charges that are detonated when an individual disturbs apparently harmless objects or performs actions that are usually considered to produce harmless consequences. Infantry squads, platoons, or patrols normally encounter these devices while on dismounted offensive or reconnaissance operations.

When requested, mine detection assistance may be provided to tactical units in the form of engineers with mine detectors and trained mine/tunnel dogs. However, the use of mine detectors is normally limited to roads or cleared areas. Dogs usually are not available in sufficient numbers to accompany all infantry units on operations. As a consequence, infantry units depend primarily on the ability of selected individuals (the point and slack men) to detect mines as they move through an area. The individuals designated for this task are usually riflemen or other members of a rifle squad or patrol (MOS 11B20 through 11B40).

The point man bears the major responsibility for detecting mines and boobytraps. He usually operates a short distance in front of his unit as it maneuvers through its area of operation. In addition to his detection responsibility, he is required to search for signs of enemy presence. The point man is usually backed up by the slack man who has the responsibility of covering the point man and assisting in the detection effort.

The point man normally communicates with his unit by hand and arm signals or by voice when the unit leader moves up to the point position. The point element is rested periodically either through replacement or during unit breaks. It is a common custom to identify unit members who have better than average detection skill and assign to them the point or slack man responsibilities. Individuals charged with detection responsibility at the unit level normally do not use mechanical or electrical devices as aids in the detection task during off-road operations. However, they may use nonmechanical items such as probes or light sticks (for detecting tripwires).

Point and slack men use a variety of tactics and techniques that are based on their training and experience. For example, detectors in Vietnam usually had received only a limited amount of countermine training in CONUS, which then was supplemented by additional instruction from their overseas unit and by a gradual breaking-in process during their initial exposure to combat operations.

Much of the initial CONUS landmine warfare training is oriented toward conventional U.S. Army mine-laying techniques. The portion of this training that was related to detection placed substantial emphasis on (a) what to look for, by describing the characteristics of typical enemy devices, and (b) where to look, by discussing the enemy's typical methods of employing these devices. The next step in this training process required the individual to negotiate mine and boobytrap lanes of varying degrees of difficulty. The final stage of training overseas provided knowledge and experience specific to the area of operations in which the individual would work.

From analysis of the job model inputs, the following parameters were identified as having an impact upon the performance of the detection job:

(1) Mode of unit operation—mounted vs dismounted.
(2) Amount of available light—daylight vs night.
(3) Detection assistance—assistance vs no assistance.
(4) Operations area—on-road vs off-road.
(5) Individual skill level of personnel performing detection job—MOS 11B20 through 11B40.
(6) Duties performed in addition to detection job—none vs some.
(7) Number of men performing the job—one vs two or more.
(8) Amount of rest the man performing the job receives.
(9) Use of detection aids—none vs some.
(10) Amount and type of prior detection training.
(11) Amount and type of practical experience in the detection job.
(12) Amount of basic mine and boobytrap knowledge.
(13) Amount of knowledge of specific mine and boobytrap devices.
(14) Amount of knowledge of specific mine and boobytrap activation methods.
(15) Amount of knowledge of enemy emplacement tactics.

(16) Knowledge of the current intelligence concerning mines and boobytraps in an operations area.
(17) Knowledge of mine and boobytrap detection signs.
(18) Techniques used to search for mines and boobytraps.

It is clear from consideration of these parameters that the following individual difference variables probably play an important part in detection performance:

(1) Individual skill level (MOS).
(2) Amount and type of detection training received.
(3) Amount and type of detection experience.
(4) Acquired and current knowledge of the types of mines and boobytraps sought.
(5) Acquired and current knowledge of the use of mines and boobytraps by the enemy.
(6) Knowledge of the cues associated with the presence of mines and boobytraps.
(7) Search techniques used during detection.

The Job Model Outputs

During the completion of the detection job, the detector can be expected to perform the following tasks:

(1) Search by (a) looking ahead in the direction of movement for signs of the enemy or mines and boobytraps, (b) bringing the gaze back in looking to the left and right of the planned direction of movement, and (c) checking the areas to the immediate front.
(2) Move slowly, steadily, and carefully during detection effort.
(3) Maintain alertness for sounds and smells indicative of enemy personnel during detection effort.
(4) Maintain alertness for signs of mines and boobytraps during detection effort.
(5) Maintain patience during detection effort.
(6) Maintain persistence during the detection effort.
(7) Look for man-made objects in the operations area.
(8) Look for known warning signs that the enemy typically uses to warn the local inhabitants of the presence of mines and boobytraps.
(9) Look for camouflage that is inadequate, wilted, or out of place with the immediate surroundings.
(10) Look for partially exposed mines and boobytraps.
(11) Look for exposed triggering devices.
(12) Look for signs of recent human presence, as listed below, and indicators of possible mine and boobytrap activity in the operations area:
  (a) Young trees that have been bent and/or bruised.
  (b) Branches that appear to have been bent, broken, cut, or squashed.
  (c) Leaves that appear to have been disturbed or walked on.
  (d) Roots that have been bruised.
  (e) Grass that is bent, broken, or changed in color.
  (f) Grass that contains material which may have come from combat boots.
  (g) Small hair-like vine filaments on the bark of trees.
  (h) Vines that have sap flowing out of cuts or nicks.
  (i) Disturbed or squashed moss.
  (j) Large and small plants that appear to have been disturbed.
  (k) Rocks at the exit from a stream that appear to have had water splashed on them.

(l) Stones and/or rocks that appear to have been disturbed.
(m) Dead logs that appear to have been stepped on.
(n) Disturbed or damaged worm casts (wet or dry).
(o) Exposed earth.
(p) Footprints and scrapes in the sand- soft terrain, along stream banks, in shallow water, etc.
(q) Disturbed water.
(r) Dew that has been disturbed.
(s) Ashes from a fire (hot or cold).
(t) Disturbed cobwebs.

(13) Develop a general knowledge of the enemy's tactics/techniques for employing mines and boobytraps.
(14) Study recent mine and boobytrap incident reports.
(15) Identify new and unusual techniques and devices reportedly being currently used by the enemy.
(16) Discuss enemy mine and boobytrap activities with intelligence and operations personnel.
(17) Study mine and boobytrap maps (plots of recent mine and boobytrap activities) compiled by own and adjacent units.
(18) Study mine and boobytrap photographs compiled by own and adjacent units.
(19) Study after action reports for details regarding enemy use of mines and boobytraps.
(20) Study mine warfare notes for details regarding the use of mines and boobytraps.
(21) Discuss enemy mine and boobytrap activities with fellow soldiers.

Upon detection of a device or cues associated with a device's presence, the detector will pass the information about the detection back to the other members of the unit.

After finding indications of a mine or boobytrap, the detector will investigate further to confirm the detection and identify the type of device located. He will then be able to make a more complete report to his unit and associated elements.

From consideration of the job model outputs, the following parameters (which themselves are not output variables) were identified as having an impact on the performance of the detection job:

(1) Search technique employed during detection.
(2) Speed of movement during search.
(3) Alertness manifested during detection effort.
(4) Patience manifested during detection effort.
(5) Persistence manifested during detection effort
(6) Knowledge of nature of the mines and boobytraps being sought.
(7) Knowledge of the cues associated with the presence of a mine or boobytrap.
(8) Knowledge of the current enemy tactics and techniques in the use of mines and boobytraps.

From this list of parameters, it is easily seen that the following individual difference variables are likely to affect the performance of the detection job:

(1) Search techniques.
(2) Individual motivation.
(3) Speed of movement during search.
(4) Knowledge of the types of mines and boobytraps sought.
(5) Knowledge of the cues associated with the mines and boobytraps sought.

The Psychological Analysis

The effective use of the eye during surveillance to detect targets of military value depends primarily upon the man behind the eye. The raw data of the military environment are filtered by the user for information relevant to his goal set, that is, his instructions or orders. This process is characterized by selectivity, which implies an active process in which current sensory input is integrated with relevant background information. A basic question that follows from this analysis concerns the nature of this selection process, whether individual difference variables affect it, and whether it is trainable to high skill levels. The present section addresses this question.

Detection consists of sensing objects. Before an object of interest can be discriminated from other objects in the environment, it must be registered in some way. This can occur only if the object becomes distinct from its background. The emergence of an object from its background usually requires some increment of time. Further, this emergence will occur only if the difference threshold of that object in the environment is exceeded. The difference threshold of the object will depend significantly on object/background parameters such as sharpness of object contours, background homogeneity, object contour integrity, object/background contrast, atmospheric attenuation, and so on.

Based on the preceding analysis, it appears logical to assert that a basic requirement of the detection process is sensitivity to a difference in the environment that signals the presence of a target object. The difference threshold varies according to the values of other variables. Further, the "difference" itself implies that the observer has some standard or base against which to compare his immediate visual experience. This base logically could originate from prior learning—for example, instruction as to the shapes and sizes of hostile target objects. Or, it might exist in the form of some sort of comparison process, in which the observer compares one part of the environment with another. As an example, regularities in the ordinarily non-regular environment might serve to generate a "running standard" that changes with the environment, and is derived from that environment. In either case, the intensity of the stimulus must exceed the difference threshold of the observer for that object in that environment. Part of the problem of studying detection, therefore, is to learn how difference thresholds are affected by environmental factors and individual differences among observers.

In addition to visual detection, it is necessary to consider cognitive detection, which supplements the visual detection process. This consists of determining that objects are present when there is no direct visual image of the object. Cognitive perception consists of deduction, inference, or some other such process. It usually is based on stimulus inputs that are typically associated with the physical presence of the objects. Cognitive detection probably is heavily dependent on the integration of environmental information believed relevant to the target objects, and on deductions from the integrated information. That is, it is considerably more than just a function of bare sensory input. The non-sensory processes of judgment, cognition, and deduction are involved and important.

Recognition is sensing or noticing objects that have significance. This implies that the objects are distinguished from the environment and labeled as having significance, but without further specific labeling. An implication of this definition is that the observer has used more information than that obtained from immediate visual stimuli. Identification is the process of specifically labeling an object of significance. It is a natural consequence of further information gathering, following initial detection, and also involved judgmental processes.

From this analysis of visual, cognitive, and military detection, it is possible to identify aptitudes that are likely to be involved in the detection process. These are summarized as follows:

(1) Aptitude for the discrimination of environmental change.
(2) Aptitude for separating figure from ground in natural environments.

(3) Aptitude for determining and extracting relevant stimulus information from a stimulus array.
(4) Aptitude for integrating partial stimulus information with current memories to accomplish a task.
(5) Aptitude for making deductions from both full and partial stimulus information.
(6) Aptitude for integrating internalized, specialized knowledge with current task results to accomplish specialized tasks.

The Literature Review

This section will present the results of the literature review, but will not deal with individual studies. Examination of *Psychological Abstracts* for the period 1962-1972 identified 190 candidate studies that seemed to be concerned with the effect of individual difference variables on visual discrimination. These studies were read to assess their relevance to human mine detection performance. Only 19 were ultimately judged to be relevant. Table I summarizes the variables identified in this search.

Table I

Individual Differences Associated With Visual Discrimination Performance Identified Through Literature Review

Age (5, 12, 13, 17, 19)
Cultural Affiliation (16)
Dogmatism (15)
Fatigue (6)
Intelligence (7, 19)
Manifest Anxiety (3, 11, 14)
Past Visual Discrimination Experience (2, 4)
Perceptual Style (18)
Religious Affiliation (15)
Sex (Male vs Female) (1)
Smoking Habit (Presence of, 19)
Visual Acuity (8, 10)

Note: Numbers in parentheses refer to items in Selected Bibliography

Identified Candidate Predictor Variables

The objective of *Task A* was to identify a set of candidate predictor variables for mine and boobytrap detection performance. Table II summarizes the variables identified from analysis of the inputs and outputs of the detection job, the psychological analysis of mine and boobytrap detection, and the literature review of visual discrimination performance. Specific individual differences are listed under each of the following categories:

(1) Physical characteristics
(2) Personal characteristics
(3) Mental characteristics

(4) Personality characteristics
(5) Native aptitudes
(6) Acquired skills
(7) Acquired knowledge

Table II

Individual Difference Variables Identified During Task A

Physical Characteristics

Age
Sex
Visual Acuity

Personal Characteristics

Cultural Affiliation
Presence of a Smoking Habit
Religious Affiliation
Speed of Movement

Mental Characteristics

Intelligence

Personality Characteristics

Dogmatism
Individual Motivation
Manifest Anxiety
Perceptual Style

Native Aptitudes

Aptitude for Discriminating Environmental Change
Aptitude for Separating Figure From Ground
Aptitude for Determining and Extracting Relevant Stimulus Information
Aptitude for Integrating Partial Information With Current Memories
Aptitude for Making Deductions From Partial and Complete Information
Aptitude for Integrating Special Knowledge With Task Results

Acquired Skills

Background Experience (Skill Level; MOS)
Formal Training (Search Techniques; Amount and Type of Detection Training)
Combat Experience (Amount and Type of Detection Experience)

Acquired Knowledge

Acquired and Current Knowledge of Types of Mines and Boobytraps
Acquired and Current Knowledge of Use of Mines and Boobytraps
Knowledge of Cues Associated With the Presence of Mines and Boobytraps

A total of 24 individual difference variables were identified by this work as potentially predictive of human mine detection performance. These results indicated that there should be individual differences that are significantly related to field criterion performance. To test the theoretical relationship between these variables and actual detection performance, the field validation discussed in Chapter 2 was conducted. The results of this validation served to establish the specific variables that were related to field detection performance.

Chapter 2

VALIDATION OF CANDIDATE PREDICTOR VARIABLES

BACKGROUND

A primary goal of the USAMERDC Human Mine Detector Research Program is to identify individual skills and aptitudes required for effective perceptual detection. In *Task A*, 24 individual differences were identified as potentially predictive of human mine detection performance (see Table II). The primary purpose of *Task B* was to validate the research results of *Task A* to discover which of the identified individual differences are significantly related to and predictive of detection performance.

APPROACH TO THE *TASK B* PROBLEM

The validation of the identified candidate individual differences was accomplished in two steps. First, predictor measures for mine and boobytrap detection performance were developed. Second, the developed predictor measures were validated against field detection performance.

Predictor Measures Development

From the list of individual differences shown in Table I, a set of 17 variables were judged to be amenable to practical assessment by HumRRO researchers (see Table III).

Table III

Individual Difference Variables Judged to be Amenable to Practical Measurement

Physical Characteristics

- Age
- Visual Acuity

Personal Characteristics

- Presence of a Smoking Habit
- Religious Affiliation
- Speed of Movement

Personality Characteristics

- Dogmatism
- Individual Motivation
- Manifest Anxiety
- Perceptual Style

Native Aptitudes

- Aptitude for Discriminating Environmental Change
- Aptitude for Separating Figure From Ground
- Aptitude for Determining and Extracting Relevant Stimulus Information
- Aptitude for Making Deductions From Partial Information

Acquired Skills

- Background Experience (Skill Level; MOS)
- Formal Training (Search Techniques)

Acquired Knowledge

- Acquired and Current Knowledge of Types of Mines and Boobytraps
- Acquired and Current Knowledge of Use of Mines and Boobytraps

Next, ten paper-and-pencil tests and one performance test were identified to measure 14 of these variables (see Table IV). Three of the selected variables (speed of movement during search,[1] search techniques, and individual motivation) were judged to be best measured during the completion of the field detection proficiency test. Procedures for measuring these individual difference variables were developed and implemented during the completion of the field proficiency test.

Table IV

Paper-and-Pencil and Performance Tests Identified to Measure the Individual Differences Judged to be Amenable to Practical Assessment

Test	Individual Difference Assessed
Personal Information Form	Age Duty MOS
Test of Visual Acuity	Visual Acuity
Personal Characteristics Inventory	Presence of a Smoking Habit Religious Affiliation
Rokeach's Dogmatism Scale (IDENTIFY Opinion Questionnaire)	Dogmatism
IDENTIFY MA Scale	Manifest Anxiety
ETS Embedded Figures Test (Short Form Modified for Group Presentation)	Perceptual Style Aptitude for Separating Figure From Ground
IDENTIFY Information Extraction Test	Aptitude for Determining and Extracting Relevant Stimulus Information
IDENTIFY Incomplete Objects Test	Aptitude for Making Deductions From Partial Information
IDENTIFY Change Detection Test	Aptitude for Discriminating Environmental Change
IDENTIFY Mine and Boobytrap Information Test	Acquired and Current Knowledge of Types of Mines and Boobytraps Acquired and Current Knowledge of Use of Mines and Boobytraps

In addition to the variables shown in Table II, the following variables were judged to have some likelihood of being associated with detection proficiency: height, weight, team orientation, types of specialized civilian training completed, means by which a high school diploma was obtained (graduation from high school or completion of the tests of General Educational Development), level of activities participation, level of background confidence, level of background despair, level of stress resistance, and race. The tests used to measure these variables are shown in Table V.

The tests shown in Tables IV and V are described in the following paragraphs:

Personal Information Form. This HumRRO form was designed to collect two types of information on the form: write-ins (name, social security number, current duty MOS, age, height, weight, specialized training) and completions (number of

[1] Speed of movement during search is defined as the rate at which an individual walks while searching for mines and boobytraps.

Table V

Paper-and-Pencil Tests Used to Measure the Individual Difference Variables Judged to Have Some Likelihood of Being Associated With Detection Proficiency

Test	Individual Differences Assessed
Personal Information Form	Height Weight Types of Specialized Civilian Training Completed Number of Years of Civilian Education Completed Means by Which a High School Diploma was Earned Race
Activities Inventory	Level of Activities Participation Level of Background Confidence Level of Background Despair Level of Stress Resistance
TTM Questionnaire	Team Orientation

years of civilian education, means by which high school diploma was earned, and race). In addition, this form provided for assessment of the combat and detection experience of the respondent. Finally, there was a space for recording the results of a visual acuity examination.

Test of Visual Acuity. This performance test required the examinee to indicate the direction (left, right, up, down) that upper case Es (subtending various visual angles) were pointing on a standardized eye chart. Es subtending the same visual angle appeared on the same line. From the top to the bottom of the chart, the size of the visual angle subtended by the Es on each row decreased from 10 to 0.5 minutes of an arc. To complete the test, the examinee stood twenty feet from the chart, which was placed upright in a well-illuminated room. The examinee was asked to read the top row on the chart (which contains just one E) and indicate the direction the E on this line was pointing. The examinee was asked to repeat this procedure successively for each lower row on the chart. The examiner recorded the number of correct answers made on each row. Then he determined the examinee's visual acuity according to the number of answers correct on each row. In general, the more rows responded to correctly, the better was the examinee's visual acuity.

Personal Characteristics Inventory. This HumRRO form was designed to elicit information about the respondent's smoking habits and his religious affiliation. First, the respondent indicated whether he currently smoked. If so, he indicated for how long he had smoked, what he smoked, and how much he smoked during a day. Then he specified his religious affiliation and indicated whether he currently attended the services sponsored by his designated faith. The answers to the questions concerning the respondent's religious faith were made on a voluntary basis.

Rokeach's Dogmatism Scale. This is a 40-item scale designed to measure the extent to which an individual has a dogmatic (closed) belief system. It has been shown to have a test-retest reliability of .71 (5-6 months) and a split-half reliability of .78 (corrected). Further, scores from this scale are related to the difficulty an individual has in solving a problem after established belief systems are overcome.[2]

[2]Rokeach, M. *The Open and Closed Mind*, Basic Books, New York, 1960.

IDENTIFY MA Scale. This 16-item scale is designed to measure the level of manifest anxiety characteristic of an individual. The items were derived from a version of the Taylor Manifest Anxiety Scale (TMAS) modified for use in Army training research.[3] Eight items (one from each of the eight content areas covered in the Army scale) were combined with eight filler items from the same scale, to make up the IDENTIFY MA Scale. A high score on this scale reflects a high degree of manifest anxiety, while a low score reflects a low degree of anxiety.

ETS Embedded Figures Test. This 12-item test is designed to measure the facility with which an individual can locate simple geometric figures hidden within complex geometric forms. The 12 items comprising the test were selected by Jackson, Messick, and Myers[4] from the 24 items comprising the Witkin Embedded Figures Test.[5] The test is group administered and requires the examinee to remember a previously shown simple figure when a particular complex figure is being scanned. In addition, 11 of the 12 complex figures are colored. All simple figures are uncolored. The score on this test is the number of correct identifications made in ten minutes. The correlation between this test and an individually administered version is .72 (N = 52 males). Jackson, Messick, and Myers[6] suggest that this group test closely measures what the individually administered form of the Witkin Embedded Figures Test measures, that is, perceptual style (field independence-dependence).

IDENTIFY Information Extraction Test. This is a 60-item experimental test developed for Project IDENTIFY. It requires the examinee to follow specific directions to locate a particular letter embedded within a large array of letters. Examinees have ten minutes to complete the 60 items. It was expected that examinees with a high aptitude for determining and extracting relevant stimulus information would produce more correct responses than examinees with a low aptitude in this area.

IDENTIFY Incomplete Objects Test. This 10-item experimental test was also developed for Project IDENTIFY. It requires the examinee to view pictures of incompletely drawn objects and determine what the objects are. Examinees have three minutes to complete the test. It was expected that examinees with a high aptitude for making deductions from partial information would produce more correct responses than examinees with a low aptitude in this area. The items for this test were extracted from the Gestalt Completion Test (Cs-1) developed by the Educational Testing Service.[7]

IDENTIFY Change Detection Test. This 10-item test is designed to measure the aptitude for discriminating environmental change. For each item, examinees were required to view two pictures of the same scene in succession and determine what had changed from the first to the second picture. A change could be the addition of an object, the removal of an object, or the change in position of an object. The time limit for this test was four minutes.

[3] Hammock, Joseph C. *Anxiety Scales for Use in Army Training Research*, HumRRO Staff Memorandum, June 1954.

[4] Jackson, D., Messick, S., and Myers, C. "Evaluation of Group and Individual Forms of Embedded Figures Measures of Field Independence," *Educational and Psychological Measurement*, vol. 24, 1964, pp. 177-192.

[5] Witkin, H.A. "Individual Differences in Ease of Perception of Embedded Figures," *Journal of Personality*, vol. 19, 1950, pp. 1-15.

[6] Jackson, D., Messick, S., and Myers, C. "Evaluation of Group and Individual Forms of Embedded Figures Measures of Field Independence," *Educational and Psychological Measurement*, vol. 24, 1964, p. 189.

[7] Educational Testing Service. *Gestalt Completion Test*, 1962.

IDENTIFY Mine and Boobytrap Detection Information Test. This is a nine-item test to measure the acquired and current knowledge possessed by an examinee concerning the types and uses of mines and boobytraps. Examinees were given as long as they required to complete the test, but were encouraged to finish within 20 minutes.

Activities Inventory. This is a two-part inventory developed at HumRRO Division No. 3.[8] Part I consists of a list of 30 activities frequently engaged in by young males during their school-age years. To complete Part I, an examinee indicates the frequency (never, few times, often, very often) with which he has engaged in each of the 30 activities. The average of these frequencies over the 30 activities provides an index of the examinee's activities participation.

To complete Part II, an examinee indicates for each Part I activity how often he has had feelings of confidence and feelings of despair when completing the activity. From the responses to Parts I and II, a numerical index of the examinee's background confidence, his background despair, and his resistance to stress is computed.

Since the inventory was designed to measure individual resources believed to have direct relevance to stress resistance in physical harm situations, it was expected that the measure derived might be predictive of detection proficiency.

TEM Questionnaire. This is a 24-item inventory designed to measure the extent to which an individual is team oriented, that is, team-task motivated. A high score on this inventory reflects a team-oriented disposition, while a low score reflects a self-oriented disposition. Test items were selected from an item pool (N = 78) developed during Work Unit UNIFECT I at HumRRO Division No. 4. It was expected that level of team orientation might be related to detection proficiency, since individuals who score high on sets of team task motivation items tend to act for other team members when doing so will clearly improve a team's overall performance.[9]

Validation of Predictor Measures

The paper-and-pencil tests and the performance test were organized into a test battery requiring approximately three hours to complete. The test battery was administered to 111 male enlisted personnel stationed at Fort Benning, Georgia who were Infantry Advanced Individual Training (AIT) graduates. After completion of the test battery, 106 of these men were given a test of mine and boobytrap detection proficiency constructed in a wooded area of Fort Benning. During this test the individual difference variables specific to the operational situation were assessed. In addition, the antitank mine detection proficiency of these men was evaluated in an open country and in a road environment. These latter assessments were performed to collect human factors data on detection rates and distances for these environments.

Since it was desired to limit the generality of the validation to combat-naive military personnel, the data from two men with combat experience were omitted from the analysis of the validation data. Thus, the validation of the predictor measures was based on 104 enlisted, combat-naive, Infantry AIT graduates, since seven were dropped from the study because of incomplete data (N=5) or because they were not combat naive (N=2).

[8] Kern, Richard P. *A Conceptual Model of Behavior Under Stress With Implications for Combat Training*. HumRRO Technical Report 66-12, June 1966.

[9] Unpublished results from Work Unit UNIFECT, 1966.

Implementation Procedures for the Validation

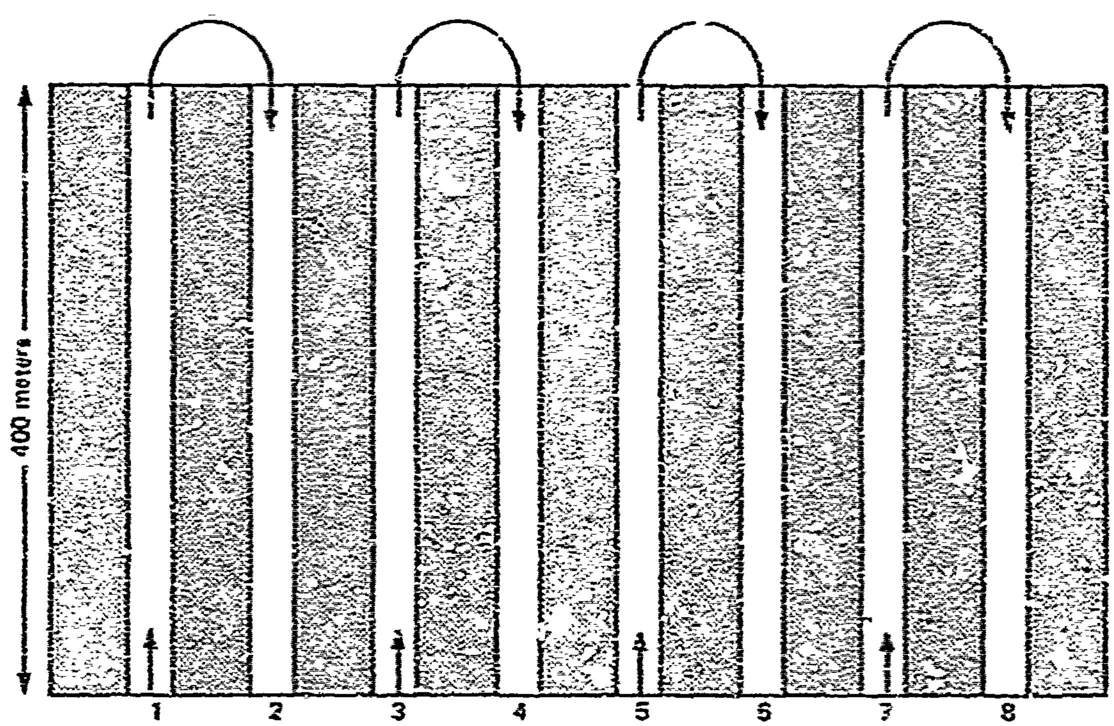
The subjects for the validation were tested in eight-man groups. The men wore fatigues, boots, helmets, and a web belt with poncho and canteen. In addition, they carried an M16A1 rifle. Subjects were furnished by the 197th Infantry Brigade during the period of 12 March 1973 through 5 April 1973.

The soldiers reported to a large room furnished with desks in the 197th Infantry Brigade area, not later than 0800 hours on each day of testing. At that time, they were briefed on the purpose of the day's testing. Next, the paper-and-pencil and performance test battery was administered to them by the Project Officer. This officer was assisted by a Research Specialist who was responsible for the distribution and collection of the testing materials, and who also monitored the men as they completed the battery. After completing the test battery, the subjects were dismissed for lunch. After lunch, they reported to the mine detection proficiency test area.

The proficiency tests were administered during the afternoon of each testing day at the Davis Hill test area on the Fort Benning Military Reservation. This area was selected for the testing because it contains the wooded terrain, open fields, and roads that might be encountered during a mid-intensity conflict in a temperate zone, the current emphasis area for U.S. Army training.

The mine and boobytrap detection proficiency test was completed on Course I (see Figure 1). This course had eight 400-meter lanes. It was located in varied terrain that

Test Course I



NOTE: This course has 20 devices per lane.

Lane

Area Between Lanes

Figure 1

required movement up and down hills, across small streams, under trees, and through a limited amount of underbrush. On this course, 20 devices were implanted on each lane. Insofar as was possible, lanes were designed to be similar as to the types of devices employed, the activation methods used, and the location of devices. The mines and boobytrap situations employed for this test were those that an infantryman might encounter in lightly wooded terrain (see Figure 2). For example, small, medium, and large devices activated by pressure, tripwire, or command detonation were used on each lane. They were located either above or below the ground and either on or off the trail. The situation created on this course required the type of performance expected of a point man during a patrolling mission.

The antitank detection proficiency tests were completed on Courses II and III. Course II (see Figure 3) had eight 80-meter lanes. The devices employed were those one

Example of the Sequence and Location of Devices on a Lane *(Test Course I)*

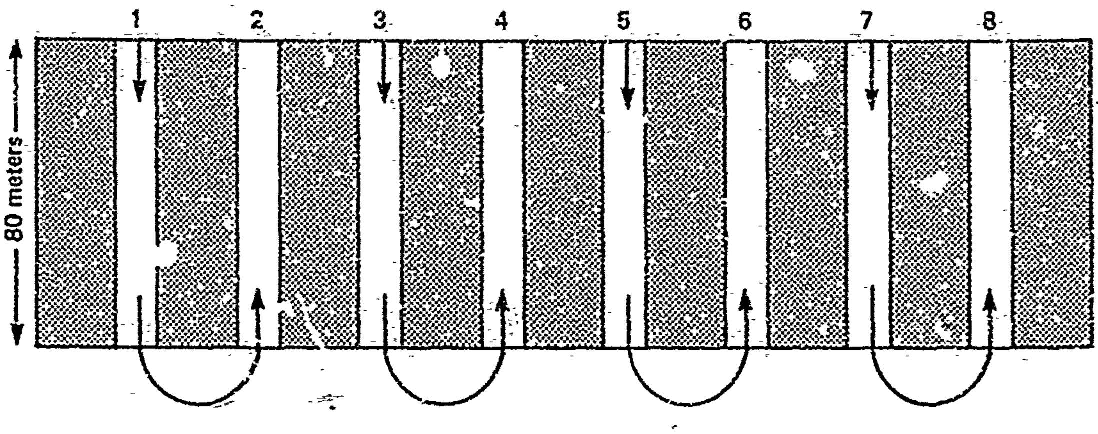
Mine and Boobytrap Information						
Device No.	Type of Device and How Activated	Device Location	Ground		Trail	
			Above	Below	On	Off
		←3m→				
1	Schumine (S) –P	•		X	X	
2	Grenade (S) –TW	•	X		X	
3	AP Mine (S) –P	•		X	X	
4	105mm Rnd (L) –CD	•	X			X
5	AP Mine (M) –P	•		X	X	
6	Grenade (S) –TW	•	X		X	
7	Schumine (S) –P	•		X	X	
8	Claymore (L) –CD	•	X			X
9	Grenade (S) –TW	•	X		X	
10	AP Mine (M) –P	•		X	X	
11	Grenade (S) –TW	•	X		X	
12	AP Mine (S) –P	•		X	X	
13	105mm Rnd (L) –CD	•	X			X
14	AP Mine (M) –P	•		X	X	
15	DH-10 (L) –CD	•	X			X
16	Grenade (S) –TW	•	X		X	
17	Schumine (S) –P	•		X	X	
18	Claymore (L) –CD	•	X			X
19	AP Mine (S) –P	•		X	X	
20	AP Mine (M) –P	•		X	X	

Summary of Devices Per Lane

LEGEND	NO. TYPE	NO. LOCATION
P – Pressure	10 – P	10 – Above Ground
TW – Trip wire	5 – TW	10 – Below Ground
CD – Command Detonated	5 – CD	15 – On Trail
S – Small	11 – S	5 – Off Trail
M – Medium	4 – M	
L – Large	5 – L	

Figure 2

Test Course II



NOTE: This course has 5 devices per lane.

Lanes

Area Between Lanes

Figure 3

would expect to encounter in a situation where mines have been laid to block a high speed armor approach (see Figure 4). To simulate this situation, five devices were implanted on each lane: two pressure activated antitank mines, a tilt-rod activated antitank mine, and two antipersonnel mines. Lanes were constructed insofar as possible to be similar in terms of activation method and device location.

Example of the Sequence and Location of Devices on a Lane
(Test Course II)

Mine and Boobytrap Information						
Device No.	Type of Device and How Activated	Device Location	Ground		Trail	
			Above	Below	On	Off
		← 3m →				
1	AT Mine (L) —P	•		X	X	
2	Schumine (S) —P	•		X	X	
3	AT Mine (L) —P (Tilt Rod)	•		X	X	
4	AP Mine(M) —P	•		X	X	
5	AT Mine (L) —P	•		X	X	

Summary of Devices Per Lane

LEGEND	NO. TYPE	NO. LOCATION
P — Pressure	5 — P	0 — Above Ground
AT — Antitank	3 — AT	5 — Below Ground
AP — Antipersonnel	2 — AP	5 — On Trail
S — Small	1 — S	0 — Off Trail
M — Medium	1 — M	
L — Large	3 — L	

Figure 4

The devices implanted on Courses I and II were concealed so that they would be moderately difficult to detect, while allowing some cues associated with their presence to exist. These cues (see Table VI) were the type that might be noted after a device had been in place for a short time.

Table VI

Basic Cues Associated With the Presence of Devices Emplaced on Courses I and II

Variation In:

Color
Camouflage
Vegetation
Soil
Size
Shape
Object Texture

Errors in Device Concealment:

Inadequate camouflage
Failure to renew camouflage
Continued use of same technique
Disturbed soil
Disturbed vegetation
Mine or boobytrap exposed
Triggering device exposed
Anticipated by tactical conditions

The lanes on Courses I and II were approximately three meters wide and did not follow a previously laid trail. The areas in which the lanes were built were left in their natural state insofar as possible. Maintenance was performed on the lanes in the morning hours of each test day to insure a uniform state of readiness for the afternoon testing. When lanes were judged to be excessively worn, they were shifted to an adjacent unused area. A minimum distance of 25 meters was maintained between lanes on each course to minimize the observation of one subject by another. In addition, when a man was traversing a lane, the lanes on either side were kept clear to further minimize interference from other soldiers.

Course III was a 200-meter section of a dirt and gravel road (see Figure 5). Ten antitank mines—five medium (8″) and five large (12″)—were buried approximately one inch under the roadbed. These were emplaced on the left and right shoulders, to the left and right of the middle and in the middle of the road. The problem created on this course was designed to simulate the situation an infantryman would face during a road-clearing operation conducted on an unpaved road suspected of being mined. It was expected that the primary cue for detection on this course would be disturbed soil. Maintenance was also performed on this course during the morning hours to insure its readiness for afternoon testing.

On arrival at the Davis Hill test site, each eight-man group was divided into two sub-groups. Men in Group I were assigned the numbers one through four, while men in

Sequence and Location of Devices on Course III

At Mine	
No.	Type
1	Large (L)
2	Medium (M)
3	L
4	L
5	M
6	L
7	M
8	L
9	M
10	M

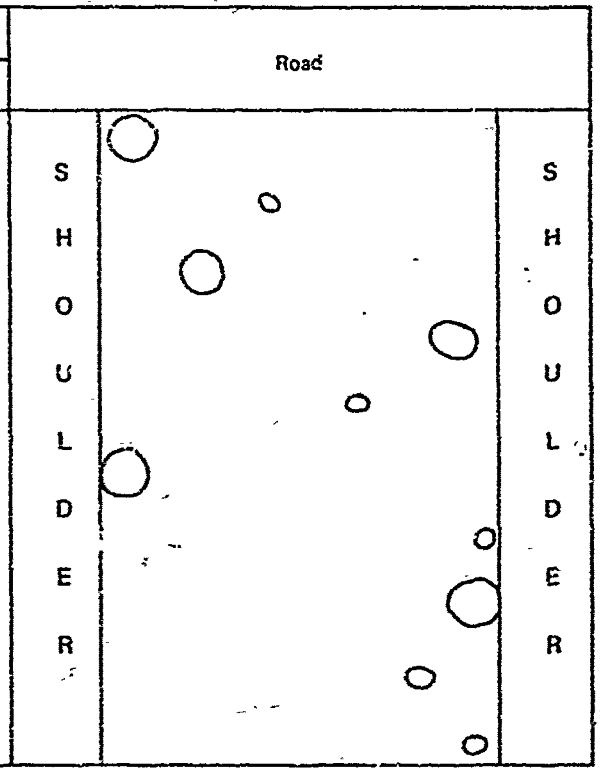


Figure 5

Group II were assigned the numbers five through eight. The men then completed the three test courses according to the schedule in Table VII.

Prior to completing the proficiency tests, the men received a short lecture on the subject of mine and boobytrap detection. They were reminded of basic detection instruction that should have been covered during previous training. Next, they were provided with specific information about the devices and employment techniques likely

Table VII

Schedule of Course Completion for Each Day of Testing

Group	Subject	Course I	Course II	Course III
I	1	1st	2d	3d
I	2	1st	2d	3d
I	3	1st	3d	2d
I	4	1st	3d	2d
II	5	3d	1st	2d
II	6	3d	1st	2d
II	7	3d	2d	1st
II	8	3d	2d	1st

to be encountered on the three test courses. This information approximated the intelligence information an infantryman might expect to receive prior to an operation in an unfamiliar area. The men were then given instructions on the observation methods used by experienced detectors. They were advised to use a systematic approach during the testing to insure coverage of critical areas. Next, they received instruction in the basic cues that may indicate the presence of mines and boobytraps. Finally, they were shown a few samples of concealed devices.

The men were then told to assume that: (a) they were in a tactical situation, acting as a point man for their small reconnaissance patrol, (b) their operations area was known to contain various types of mines and boobytraps, and (c) their mission was to visually locate these devices so a path could be cleared through the area. They were instructed to walk through their test area at a pace they considered appropriate for a point man in an area where mines and boobytraps might be anticipated. The men were told to move along until they thought they saw something that indicated the presence of a mine or boobytrap, and then to stop. Upon stopping, they were instructed to point to the location of the suspected device, state verbally the nature of the detection cue that indicated the presence of the device, and wait for the accompanying evaluator to tell them to start moving again.

Subjects were allowed to bend at the waist to look at a suspected area while they were moving but could not crouch down to look closely at an area. Also, they could not brush away any material to confirm an identification. Since the emphasis during the testing was on visual detection, the men were not allowed to use sticks or rods to aid in detection.

After the men received all testing instructions, evaluators took them to their appropriate starting points. The evaluators reviewed the instructions with each subject, prepared the evaluation forms, and then commenced the testing.

As each man moved from his starting point, his evaluator activated a stopwatch and followed the subject, observing him carefully. When a man stopped and pointed to a suspected device, the evaluator stopped the watch and recorded the elapsed time. Next, he recorded the verbal report of the cue that the man used for his detection. Finally, he recorded the estimated distance to the suspected device and indicated if the sighting was an actual detection or a false detection. Evaluators did not indicate to the men whether a detection was actual or false. When damage to a course occurred through the action of a subject, the evaluator repaired the damage so the course was restored to its original condition and ready for the next subject.

On Courses I and II, each man successively completed two lanes, one odd numbered and one even. The subject went out on the odd numbered lane and finished up on the even numbered lane. He traversed Course III only one time. Upon completion of a course, the evaluator returned the subject to an assembly point and recorded the search technique used by the subject. He also rated the degree of detection effort expended on a five-point scale (unsatisfactory to outstanding). Evaluators were told to make these ratings on the degree of effort exhibited by the subject rather than on detection success. Finally, the evaluator collected all the evaluation materials, turned these in, and prepared to test another subject. After all subjects had been tested on all courses, the men were dismissed, and testing was declared complete for the day.

RESULTS

Validation Pilot Test

To test the procedures developed for the validation, provide training for the test evaluators, and establish the adequacy of the test courses, a three-day pilot study was conducted before the main study was begun. The eleven men used as subjects for this study were from the U.S. Army Infantry Human Research Unit and the staff of HumRRO Division No. 4 at Fort Benning. Based on the results of the pilot study, the staff of Project IDENTIFY concluded that, with minor modifications, the test procedures and test courses were adequate for the validation of the predictor measures. The pilot test results are not included in the present report because the subjects were not representative of the population in the main study.

Validation of the Predictor Measures

Preliminary data summaries for the candidate predictor measures listed in Table VIII indicated that an adequate data base existed for these measures and they were thus suitable for further analysis. Preliminary data summaries for Duty MOS, religious affiliation, aptitude for discriminating environmental change, and types of specialized civilian training completed indicated that these measures did not have an adequate data base and could not be analyzed further. Using a stepwise multiple regression technique, criterion detection performance (total number of devices detected on Course I) was regressed against the predictor measures shown in Table VIII. The stepwise regression process was continued until 24 of these measures were entered into the regression equation; the process was then terminated because the remaining measures did not meet the statistical criteria for inclusion in the equation. Table IX presents the multiple correlation coefficient (R) and the Standard Error (SE) of the Estimate for each step of the multiple regression process.

Table IX shows that the SE of the Estimate decreased through the eighth step of the multiple regression. The SE then began to increase and did not decrease further with the addition of other predictor measures. Furthermore, the multiple correlation coefficient did not increase substantially after the eighth step. Therefore, the eighth step was judged to provide the optimal prediction equation for criterion detection performance for the sample studied. At the eighth step, R was .76, which is highly significant ($F = 16.4$, $p < .01$, $df = 8$ and 95), and SE of R was .04 and the 99% confidence limits of R were .63 to .85.

It should be noted that the computed multiple correlation was optimal for the validation sample studied, that is, it was the best correlation that could be obtained for these subjects and their measurements. Because of sampling and error variance in the various measures, it can be expected that a computed multiple correlation will be inflated somewhat above its "true" statistical value. To investigate this, the multiple correlation was corrected for shrinkage using the procedure suggested by Uhl and Eisenberg.[10] The result was an R equal to .71. This result suggests that in predicting the criterion detection performance for a new sample of 104 subjects, using the eight predictor scores involved at Step 8 of the multiple regression, the obtained multiple correlation would be .71, which is significant at the .01 level.

Table X lists the predictor measures included in the regression equation produced at Step 8 of the multiple regression analysis. This table also shows the percentage of criterion variance associated with each measure and type of measure. Personal characteristics measures accounted for 9.6% of the predictable criterion variance, personality characteristics measures accounted for [illegible].4%, and one physical characteristics measure accounted for only .5%. Further, these results indicated that speed of movement during search/800 meters (search time) and effort expended during search together accounted for 46.5% of the predictable criterion variance. This result suggests that the criterion detection performance was largely a function of individual difference variables specific to the operational situation.

[10] Uhl, N. and Eisenberg, T. "Predicting Shrinkage in the Multiple Correlation Coefficient," *Educational and Psychological Measurement*, vol. 30, 1970, pp. 487-489.

Table VIII

Means and Standard Deviation of Each Predictor and the Criterion Measure Involved in the Stepwise Multiple Regression[1]
(N = 104)

Measure	$\bar{X}$	SD
Predictor Measures		
Age	19.6	1.4
Height	70.6	2.6
Race	.5	.5
Visual Acuity	2.1	1.0
Weight	162.9	21.2
Years of Smoking	1.6	1.6
Civilian Education Completed	11.0	1.4
High School Graduation	.7	.5
GED Tests Completed	.2	.4
Level of Dogmatism	3.6	.5
Level of Manifest Anxiety	5.8	2.9
Level of Team Orientation	13.7	4.0
Activities Participation Index	2.0	.4
Background Confidence Index	5.1	2.0
Background Despair Index	3.5	1.2
Stress Index I	3.7	1.5
Stress Index II	1.5	.5
Knowledge of Mines and Boobytraps	8.6	3.4
Knowledge of Mine Fields	4.8	2.8
Knowledge of Detection Means	2.3	1.2
Total Knowledge	15.9	5.4
Embedded Figures Test Score	4.6	3.1
Information Extraction Score	18.7	9.9
Incomplete Objects Test Score	5.2	3.1
Speed of Movement During Search/800 m.	43.4	13.6
Effort Expended in Search	3.4	.9
Search Technique	2.9	.9
Criterion Performance Measure		
Total Number of Devices Detected on Course I	24.6	5.9

[1]A matrix showing all the intercorrelations of the predictor and criterion variables is shown as Appendix A.

Table XI presents the constant and regression coefficients for the Step 8 prediction equation. This table indicates the weights given each measure in the computation of predicted criterion scores. Interpretation of these coefficients indicated there was a positive relationship between criterion performance and speed of movement during

Table IX

Multiple Correlation Coefficients (Rs), Standard Errors (SEs) of the Estimate and Variable Entered at Each Step of the Stepwise Multiple Regression[1]

Step	R	SE	Variable Entered
1	.621	4.66	Speed of Movement During Search/800 m.
2	.696	4.29	Effort Expended in Search
3	.723	4.14	Civilian Education Completed
4	.739	4.06	Activities Participation Index
5	.748	4.03	Level of Dogmatism
6	.753	4.02	Visual Acuity
7	.755	4.02	GED Tests Completed
8	.762	3.99	High School Graduation
9	.764	4.00	Height
10	.765	4.91	Level of Team Orientation
11	.767	4.02	Age
12	.768	4.03	Information Extraction Score
13	.770	4.04	Years of Smoking
14	.771	4.06	Knowledge of Detection Means
15	.771	4.07	Search Technique
16	.772	4.09	Background Despair Index
17	.772	4.11	Embedded Figures Test Score
18	.772	4.14	Total Knowledge
19	.773	4.16	Incomplete Objects Test Score
20	.773	4.18	Race
21	.773	4.21	Stress Index II
22	.773	4.23	Stress Index I
23	.774	4.25	Background Confidence Index
24	.774	4.28	Weight

[1]A matrix showing all the intercorrelations of the predictor and criterion variables is shown as Appendix A.

search, effort, years of civilian education, activities participation, earning a high school diploma by completing high school, and visual acuity.[11] On the other hand, there was a negative relationship between criterion performance and level of dogmatism, and earning a high school diploma by completing the Tests of General Educational Development.

These results suggest that the highly proficient detector can be characterized in the following manner: During the test, he moved more slowly and expended more effort during search than less proficient detectors. He had earned a high school diploma by graduating from high school. He had completed more years of civilian education than less proficient detectors, he had engaged in the activities listed in the Activities Inventory

[11]The relationship between visual acuity and detection performance was positive. The regression coefficient in Table XI is negative because low values were given to high levels of visual acuity and high values were given to low levels.

Table X

Predictor Measures Included in the Prediction Equation at Step 8 in the Multiple Regression and the Criterion Variance Predicted by Each Measure

Predictor Measure	Percent of Criterion Variance[1]
Physical Characteristics	.5
Visual Acuity	.5
Personal Characteristics	9.6
Activities Participation Index	2.5
High School Diploma Earned by Graduation From High School	3.5
High School Diploma Earned by Completion of Tests of General Educational Development (GED)	1.2
Number of Years of Civilian Education Completed	2.4
Personality Characteristics	1.4
Level of Dogmatism	1.4
Field Predictor Measures	46.5
Effort Expended in Search	17.9
Speed of Movement During Search/800 meters	28.6
All Predictor Measures Together[1]	58.0

[1] The total percentage of criterion variance predicted equals the sums of the percentages for each type of measure (underscored). Computed according to the formula described by William L. Hays, *Statistics for Psychologists*, Holt, Rinehart, and Winston, Inc., New York, 1963, pp. 570-572.

Table XI

Constant and Regression Coefficients for the Prediction Equation Formed at Step 8 in the Multiple Regression

Predictor Measure	Regression Coefficient
Activities Participation Index	2.42
Effort Expended in Search	2.01
High School Diploma Earned by Completing the Tests of General Educational Development	-2.80
High School Diploma Earned by Graduating From High School	1.95
Level of Dogmatism	-1.14
Visual Acuity	-.43
Number of Years of Civilian Education Completed	.34
Speed of Movement During Search/800 Meters	.20

Constant = 4.61

more frequently, and he was less dogmatic (i.e., more open-minded). Finally, his visual acuity was better than that of less proficient detectors.

Human Factors Data Analysis - Course I

One hundred and four men produced a total of 2605 detections on this course. Of these, 2562 (98.3%) detections were true detections, that is, a device emplaced on the course was detected. The remaining 43 (1.7%) detections were false detections, that is, a device was said to be present when no device was actually there. Each man on this course had an opportunity to detect 40 devices. The average number detected per man was 24.6 devices (SD = 5.9). The average detection rate was 61.6% (SE = 14.8%).

The following types of devices were available for detection on Course I: DH-10 (2), Hand Grenade/Tripwire Boobytrap (10), 105mm Round (4), M18A1 Antipersonnel Mines (4), M16 Antipersonnel Mines (8), Schumines (6), and M25 Antipersonnel Mines (6). Table XII shows the percent detected and the average number detected for each of these devices. Inspection of these results suggests that object size and placement of device above or below ground were significant factors affecting the detectability of the Course I devices.

Table XII

Percent Detected and Average Number Detected for Each Type of Device Emplaced on Course I

Device	Size[1]	Location[2]	% Detected	$\bar{X}$ Number Detected
DH-10 (Russian Claymore Mine)	L	A	88.9	1.8
Hand Grenade/Trip wire Boobytrap	S	A	77.5	7.8
105mm Round	L	A	68.8	2.8
M18A1 Antipersonnel Mine	M	A	67.1	2.7
Schumine	S	B	52.9	3.2
M16 Antipersonnel Mine	S	B	46.9	3.8
M25 Antipersonnel Mine	S	B	45.6	2.8

[1] L - Large; M - Medium; S - Small.

[2] A - Above ground; B - Below ground.

That size and above-ground employment were particularly important in affecting device detectability is also evident from inspection of Table XIII, which shows the average distance at which each type of Course I device was detected. Larger devices employed above ground were detected much further away on the average than smaller below-ground devices.

Human Factors Data Analysis - Course II

One hundred and four men produced a total of 761 detections on this course. Of these, 592 (77.8%) were true detections, while the remaining 169 (22.2%) were false detections. Each man had an opportunity to detect 10 devices; the average number of devices detected was 5.7 (SD = 2.1). The average detection rate for this course was 56.9% (SD = 21.4%).

The following types of devices were available for detection on Course II: M15 Antitank Mines (4), M21 Antitank Mines with tilt rod (2), M16 Antipersonnel Mines (2), and Schumines (2). Table XIV shows the percent detected and the average number

Table XIII

Average Estimated Distance at Which Each Type of Device Emplaced on Course I was Detected

Device	Size[1]	Location[2]	$\overline{X}$ Feet	SD
DH-10 (Russian Claymore Mine)	L	A	17.1	14.2
Hand Grenade/Trip wire Boobytrap	S	A	2.9	3.6
105mm Round	L	A	11.9	10.6
M18A1 Antipersonnel Mine	M	A	14.1	9.3
Schumine	S	B	1.9	2.2
M16 Antipersonnel Mine	S	B	2.6	6.7
M25 Antipersonnel Mine	S	B	2.2	1.6

[1] L - Large; M - Medium; S - Small.
[2] A - Above ground; B - Below ground.

Table XIV

Percent Detected and Average Number Detected for Each Type of Device Emplaced on Course II

Device	Size[1]	Location[2]	% Detected	$\overline{X}$ Number Detected
M15 Antitank Mine	L	B	67.5	2.7
M21 Antitank Mine (Tilt Rod)[3]	L	B	63.0	1.3
Schumine	S	B	45.7	.9
M16 Antipersonnel Mine	S	B	40.9	.8

[1] L - Large; S - Small.
[2] B - Below ground.
[3] Mine was buried, but tilt rod was exposed.

detected for each of these devices. Inspection of the results suggests that the larger devices (M15s and M21s) were more detectable than the smaller devices (Schumines and M16s). This result is comparable to findings that the detectability of Course I devices was partially a function of object size.

That size was important in affecting the detectability of the Course II devices is evident from inspection of Table XV, which shows the average distance at which each type of Course II device was detected. The larger devices were detected further away than the smaller devices. This result is particularly interesting, since it tends to confirm the results for the Course I detection distance analysis.

Human Factors Data Analysis - Course III

Only 64 men completed this course, since it was initiated and developed at the request of MERDC one week after the initiation of the validation. There were 544 detections, of which 422 (77.6%) were true detections, and 122 detections (22.4%) were false. Ten devices were available for detection on this course. The average number of true detections was 6.6 (SD = 2.5) and the average detection rate was 65.9% (SD = 24.8%).

Table XV

Average Estimated Distance at Which Each Type of Device Emplaced on Course II was Detected

Device	Size[1]	Location[2]	$\bar{X}$ Feet	SD
M15 Antitank Mine	L	B	2.5	2.2
M21 Antitank Mine (Tilt Rod)[3]	L	B	3.0	2.4
Schumine	S	B	2.1	1.4
M16 Antipersonnel Mine	S	B	1.8	1.4

[1] L - Large; S - Small.
[2] B - Below ground.
[3] Mine was buried but tilt rod was exposed.

Two types of devices were available for detection on Course III: M21 Antitank Mines (5) and M19 Antitank Mines (5). The detection rate for the M19 Antitank Mines was 57.8%, while the detection rate for the M21 Antitank Mines was 74.1%. This result indicated that the smaller mines (the M21 Antitank Mines) were less difficult to detect than the larger mines (the M19 Antitank Mines). The average detection distance for the M19 Antitank Mines was 3.0 feet (SD = 2.2), while the average detection distance for the M21 Antitank Mines was 2.6 feet (SD = 1.8). It appears, however, that while the M19 mine was less detectable, it was detected further away than the M21 mines. This result suggests that size was also a factor in detection of the Course III mines.

However, the higher detection rate that occurred for the smaller mines suggests that another factor in addition to size operated on Course III to affect device detectability. From inspection of Figure 5, it is clear that all the larger mines were away from the center of the road, while two of the smaller ones were very near the center of the road. This suggests that device location may be responsible for the lower detection rate for the larger mines. Item analysis supports this position. The smaller devices located away from the edge of the road (the second, fifth, and ninth devices), were detected at a higher rate ($\bar{X}$ detection rate = 76.6%, 82.8%, and 87.5%, respectively) than were the smaller devices located at the edge of the road (the seventh and tenth devices; $\bar{X}$ detection rate = 59.4% and 64.1%, respectively). Thus, device location was probably the other factor in addition to size that affected device detectability on Course III.

Chapter 3

SELECTION AND TRAINING IDENTIFICATION

From the results of the validation, it was clear that the primary predictors of detection proficiency were variables specific to the operational situation. This result suggests that training is likely to be the most important factor influencing the level of detection proficiency an individual can attain. However, this is not to imply that the personnel selected for detection training are not important, since the results indicated that personal and physical characteristics contributed somewhat to the prediction of detection proficiency.

Thus, the question that remains is "How can the results of the validation be developed into practical selection and training procedures to produce personnel likely to be capable of successful mine and boobytrap detection?" To develop an answer to this question, the results of the validation were reviewed to identify possible selection and training procedures. The accomplishment of this task represented the completion of the research for Project IDENTIFY.

RECOMMENDED SELECTION PROCEDURES

From analysis of the validation data, a prediction equation for criterion detection performance was developed. This equation was found to have substantial accuracy for predicting successful criterion performance. This section describes selection procedures employing this equation which can be used to identify enlisted military personnel who are likely to be proficient at detecting mines and boobytraps in wooded environments. The recommendations consist of procedures developed from analysis of the results of the validation of the candidate predictor measures. It is believed that when used properly, these procedures will ensure a high quality input to training programs designed to improve individual detection proficiency.

Selection Test Battery

To evaluate the predictive accuracy of the equation developed from the validation data analysis, successful criterion performance was defined to be the median detection proficiency demonstrated on Course I, that is, the detection of at least 25 of the 40 devices emplaced on Course I (a score of at least 62%). Detectors who scored at or above the median (62%) were labeled as "Successful," while those who scored less than the median were labeled as "Unsuccessful". Next, predicted criterion scores were computed from the equation, excluding the field measures. Using the above criterion, detectors were then classified on the basis of these predicted scores as "Successful" or "Unsuccessful". Finally, actual and predicted criterion scores were compared, to establish the extent the test measure in Table XI predicted actual success or failure.

Table XVI presents the results of the comparison. Forty-four successes were predicted. Of these, 33 men demonstrated successful performance, while 11 did not. Among the 60 men for whom unsuccessful performance was predicted, 41 demonstrated this performance, while 19 did not. Thus, the equation predicts success with 75% accuracy and failure with 68% accuracy, and the overall accuracy of the prediction

Table XVI

Comparison of Predicted and Actual Success for the Criterion Detection Proficiency Test

Actual Performance	Predicted Performance: Unsuccessful	Predicted Performance: Successful	Total
Successful	19	33	52
Unsuccessful	41	11	52
Total	60	44	104

equation is 71%. That is, if the criterion performance of 100 detectors was predicted by the equation, it would be expected that the performance of 71 would be correctly predicted. These results indicate that the prediction equation developed from the validation data can be quite useful in the selection of personnel for training for mine and boobytrap detection.

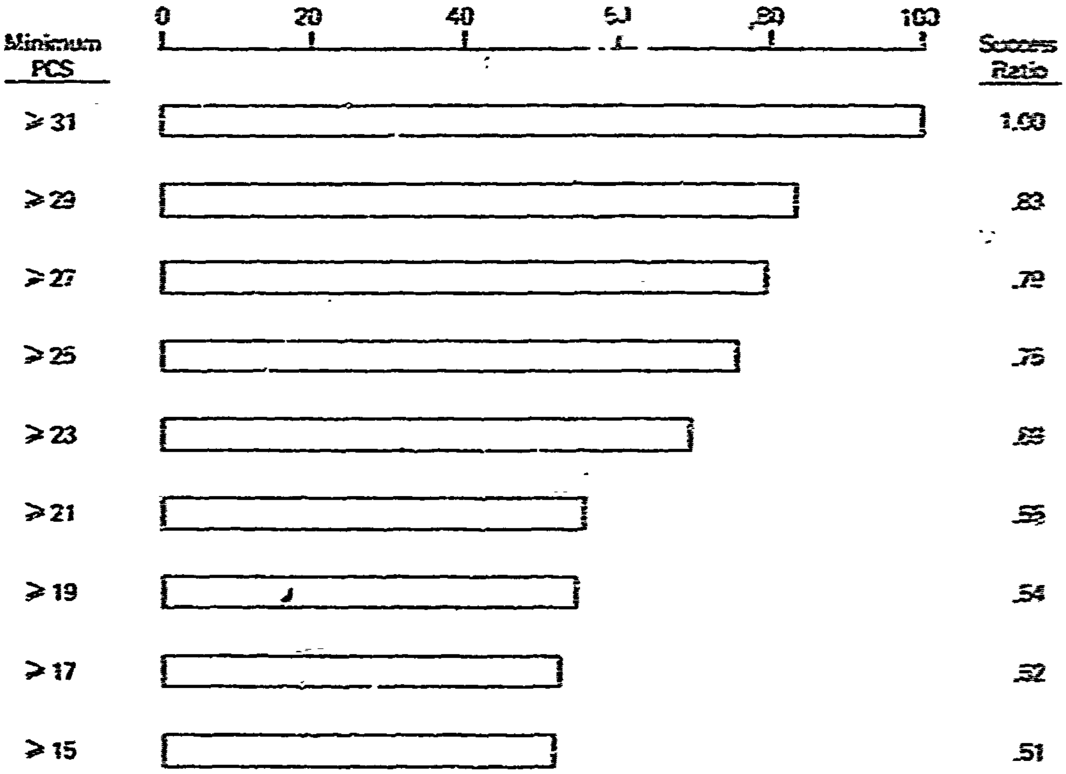
Therefore, the test battery should consist of (a) two paper-and-pencil tests (an inventory of activities participation, and a test measuring level of dogmatism), (b) a visual acuity performance test, (c) performance tests measuring speed of movement and the effort an individual appears to expend during an outdoor search task (not mine and boobytrap specific), and (d) an information form that collects the candidate's identifier, the number of years of civilian schooling completed, and whether the candidate has received a high school diploma and, if so, how the diploma was obtained.

While it is true that a gross procedure involving search speed and effort expended during search could also be employed for prediction, the recommended test battery maximizes the prediction of criterion performance. A procedure involving search speed and effort expended during search would predict 46.5% of the criterion variance. Having the paper-and-pencil tests included in the procedure increases the predictability by 11.5%, to a total of 58%. (From these tests and the information form, the predictor measure information in Table XI can be weighted to form a predicted criterion score, PCS. An individual's probability of success is estimated by this score. Different PCSs indicate different probabilities of success.)

To illustrate the range of obtained PCSs and their associated probabilities, an institutional expectancy chart was constructed (Figure 6), using the established definition of successful criterion performance of at least 62%. The chart shows for each PCS the cumulative percentage of individuals who performed successfully. For example, 75% of the individuals who achieved a PCS of 25 or higher performed successfully on the criterion test. As the PCS increased, the percentage of successful individuals increased.

To use the PCSs most effectively for selecting individuals who are currently proficient detectors, the range and distribution of the PCSs must be known. Table XVII shows the percentile ranks equivalent to various PCSs for the sample of 104 men used in the validation. The percentile rank shown for a specific PCS indicates the percentage of men who scored lower than the specified PCS. For example, the PCS of 28 is associated with the percentile rank of 77; this rank indicates that 77% of the men in the validation sample scored lower than 28. Further, if the percentile rank for a particular PCS is subtracted from 100, the value that remains indicates the percentage of men who achieved a PCS greater than or equal to the particular PCS. Continuing with the example, for a PCS equal to 28, 23% of the men in the validation sample achieved a PCS greater than or equal to 28.

Institutional Expectancy Chart Showing Percent of Criterion Success and Success Ratio[1] for Predicted Criterion Scores (PCSs)



[1]The Success Ratio was computed for each Minimum PCS by assuming an applicant pool of 100 individuals. Under these conditions the Success Ratio is equal to Percent Criterion Success divided by 100.

Figure 6

The above results have a significant implication for selection, since they indicate the number of personnel who must be tested to obtain a specified number of acceptable individuals. The number of personnel who should be tested will be determined by the cutting score which represents the breaking point between acceptance and rejection. Table XVII shows that, as the PCS used for the cutting score is increased, the percentile rank increases and, therefore, a lower percentage of individuals can be expected to achieve an acceptable PCS.

The decision as to which PCS should be designated as a cutting score should be based on two factors: (a) the probability of successful performance associated with the PCS, and (b) the availability of applicants from whom selection can be made. In general, a score that will result in modest attrition—that is, a substantial probability of success—is desirable. However, scarcity of applicants and severity of requirements for personnel may lead to a decision to choose a cutting score that is associated with a probability of success that is lower than desired.

Two additional concepts should be taken into consideration at this point. The first is the Success Ratio—the ratio of the number of individuals who succeed on a job to the number who are selected. This ratio is a function of the predictive accuracy of the test measures. For example, from Figure 6, a PCS of 25 is associated with a Success Ratio of .75.

Table XVII

Percentile Ranks and Selection Ratios for Obtained PCSs

PCS	Percentile Rank	Selection[1] Ratio
15	1	99
16	2	98
17	3	97
18	5	95
19	10	90
20	16	84
21	19	81
22	28	72
23	38	62
24	49	51
25	58	42
26	64	36
27	72	28
28	77	23
29	83	17
30	86	14
31	91	9
32	93	7
33	98	2
34	98	2
35	99	1
36	100	0

[1]The Selection Ratio was computed for each PCS by assigning an applicant pool of 100 individuals. Under these conditions the selection ratio is to (100 - Percentile Rank)/100.

The second important concept is the Selection Ratio—the ratio of the number of men selected to the total number of applicants. Table XVII shows that the PCS of 25 was associated with a selection ratio of .42, which indicates that, for every 100 applicants tested, it can be expected that 42 will obtain a PCS of 25. Thus, if a PCS of 25 is designated as the cutting score, it would be expected that 42 out of every 100 applicants would have a PCS of 25 or better. Table XVIII shows that 32 of these would actually be capable of successful detection performance, as herein defined.

For selection based on the results of this study, a PCS cutting score of 25 is recommended. It has been shown that this score is associated with a substantial Success Ratio (75%), so attrition will not be too severe. On the other hand, the Selection Ratio (42%) is such that a reasonable number of acceptable candidates can be expected. Table XVIII shows the number of applicants who will be accepted and the number of accepted candidates who would demonstrate successful detection performance as a function of different number of available applicants for the Selection Ratio of .42 and a

Table XVIII

Number of Selected Applicants and Successful Candidates as a Function of Available Applicants for a Selection Ratio of 42% and a Success Ratio of 75%

Number Available for Selection	Number Selected Selection Ratio = 42%	Number Successful Success Ratio = 75%
10	4	3
20	8	6
30	13	9
40	17	13
50	21	16
60	25	19
70	29	22
80	34	26
90	38	28
100	42	32
150	63	47
200	84	63

Success Ratio of .75. Finally, it should be emphasized that these procedures are valid only for the criterion of detection performance employed in the validation. To be applied to other detection situations, these procedures would require validation in those situations.

RECOMMENDED TRAINING PROCEDURES

Development of training procedures was accomplished by observation of successful detection behavior (behavior which led to the detection of hidden devices), by validation, and through assessment of the detection techniques that proved most successful. Each subject negotiated the field test courses accompanied by an evaluator. The evaluator recorded both correct and false detections made by the subject, the basic cues that aided the detection, the search procedure employed, the search time required, and the degree of search effort (motivation) exhibited. Analysis of these data provided the basis for suggesting improvements in detection training.

Search Speed

During his initial orientation, the detector was instructed to consider himself the point man of a reconnaissance patrol that had the mission of clearing a route through an area suspected of containing mines and boobytraps. He was also told that he could move through this area at the pace he considered appropriate for the situation. The evaluator used a stop watch to keep an accurate record of the search time used by the subject.

Analysis revealed that speed of movement during search (which was computed from the known search time) was inversely related to detection proficiency. For example, while the overall average for search speed was 18.4 m/minutes and for detection was 24.6 devices, this varied considerably between lower and higher groups. Subjects (N = 11) travelling between 28 m/min. and 40 m/min. averaged 17.4 detections, while those travelling from 12 m/min. to 13 m/min. (N = 13) found an average of 29.3 devices.

This requirement to move more slowly—that is, to use more search time—is supported by previous HumRRO research[1] in which interviews with expert detectors from Vietnam indicated that over 58% felt that they did not have enough time to search properly. Data also reflected a decrease in the rate of movement as the likelihood of encountering mines and boobytraps increased. There were numerous comments from the detectors who were assessed to be experts (N = 48) about being rushed while on operations which made the point man's task even more hazardous because of reduced detection capability.

Training Implication No. 1. The obvious training suggestion here is to stress the requirement to move slowly and carefully, when moving through an area suspected of containing these devices. Trainees should learn what an adequately slow pace feels like. Field exercises should emphasize this point and provide sufficient time so that a trainee is not rushed while he is attempting to negotiate a mine and boobytrap detection course. Training for commanders should also stress the requirement to avoid rushing detectors by providing adequate time when planning the movement of forces through an area suspected of containing mines and boobytraps.

Effort Expended

During initial orientation for the field test, the men were encouraged to put forth their best efforts to detect the concealed mines and boobytraps. However, while they were generally cooperative, it was anticipated that there would be a motivation difference between individuals. To record this difference, evaluators were instructed to rate the men on a five-point scale (unsatisfactory to outstanding) upon completion of a course. Evaluators were instructed to make these ratings on the degree of effort exhibited, rather than on detection success.

As with search time, the amount of effort put forth by an individual was related to detection success. For example, while the overall average rating for effort expended was between good and very good (3.4) and for detection was 24.6 devices, this varied considerably between groups. Subjects listed in the fair category (N = 14) averaged 20.9 detections, while those in the outstanding group (N = 11) detected an average of 30.9 devices.

The need for detectors to have a high degree of motivation was also noted in the previous HumRRO research by Maxey and Magner. Discussions with expert detectors from Vietnam indicated that many felt that volunteers should be used for this task, as they would be more likely to be motivated and therefore would probably do a better job. Many of the expert detectors also attributed their own expertise in this area to the extra effort put into this task, rather than to any special mental or physical ability.

Training Implication No. 2. There are a number of measures that can be taken in training to emphasize the importance of motivation to achieving detection proficiency. As a first step, all training of this type should include an explanation of the importance of giving a maximum effort in a detection situation. Without using "scare tactics," instruction should realistically portray the danger involved in failing to detect these devices. This can be further emphasized by the use of realistic mine and boobytrap training devices that react in some manner when not detected.

Training can also be made competitive in order to stimulate added effort. This should enable trainees to recognize the contribution of motivation to success. For example, two groups could conceal mines and boobytraps in ass[illegible]ed locations and then exchange areas to detect the other group's devices. The [illegible]nning group would be rewarded in a way that would recognize the importance of extra effort.

[1] Maxey, J.L. and Magner, G.J. *A Study of Factors Affecting Mine and Boobytrap Detection. Subject Variables and Operational Considerations*, HumRRO Technical Report 73-12, June 1973.

Training for commanders should include instruction on the importance of motivation to detection success and on methods of obtaining a detector's best efforts. These methods could include insuring that detectors are not required to perform this task for extended periods without relief, and recognizing the detectors' contribution to the success of the unit by appropriate awards or other special consideration.

Search Procedure

During the brief instruction period, procedures for detecting concealed mines and boobytraps were discussed. The instruction was oriented primarily to Course I, where danger from concealed devices might be anticipated from several directions. Possible directions to search were: above the trail (for artillery rounds placed in trees), right and left of the trail (for DH-10s and Claymores), across the trail (for tripwired grenades), and on the trail (for pressure-type antipersonnel mines).

The trainees were told that most expert detectors from Vietnam interviewed in the Maxey and Magner study said they had used a combination of area search and footfall as their primary detection technique. This procedure was described as: first, looking-out to locate anything that appeared out of place; second, looking right and left as their gaze was brought back in; and, third, looking carefully to the immediate front. It was also stated that while the expert detectors' techniques varied, all used a systematic approach to insure the coverage of all danger areas. Trainees were told to use the procedures that seem to work best for them, but a systematic approach to insure complete coverage was recommended.

No significant difference in detection success was noted on Course I among the basic procedures used. Almost half of the subjects chose to employ an area search/footfall technique. The next most frequent choice was primarily footfall with some area search (26.9%), followed by footfall (11.5%), primarily area search with some footfall (8.6%), and area search (3.8%). It is clear from these figures that most trainees used a procedure involving the footfall technique at least part of the time during detection. In some instances, evaluators observed that footfall-oriented trainees became so preoccupied with search for on-trail devices that they missed above-ground off-trail items that were relatively easy to detect. This would, of course, be extremely hazardous in a combat situation, where the presence of enemy personnel must also be considered. However, since three-fourths of all devices on this course were on the trail, the detection percentage for these individuals was not necessarily lower.

The use of the combination area search/footfall method by the highest percentage of the subjects appears to reinforce the opinion of expert detectors from Vietnam as to the value of this technique. This method would be even more appropriate for a combat situation where the threat of enemy action must be considered in addition to the mine detection task.

> <u>Training Implication No. 3</u>. The suggestion here is to include the area search/footfall procedure in the training of mine and boobytrap detectors as the recommended technique. Also, as a part of this method, detectors would be trained to use a systematic procedure to insure coverage of all danger areas.

Basic Detection Cues

During the detection instruction, trainees were told to look for certain basic cues that could assist in the detection of concealed mines and boobytraps. These basic cues were described as (a) variations in the environment and (b) enemy errors in concealing the device. Environmental cues included variations in color, camouflage, vegetation, soil, size, shape, and texture. Device concealment errors included inadequate or unrenewed camouflage, disturbed vegetation or soil, exposed triggering device, exposed mine or boobytrap, continued use of the same technique, and placement of devices in areas that can be anticipated by tactical conditions.

Trainees were told to tell their evaluator what basic cue had helped them detect a mine or boobytrap. The basic cue could be any of those in the categories discussed during the training period or others considered appropriate.

An analysis of the basic cues that were reported indicated that variations in color were listed most frequently (29.6%), followed by variations in texture (21.8%), exposed triggering devices (16.9%), and variations in shape (14.0%).

Devices detected most frequently by variations in color were the Schumine, M25 antipersonnel mine, M16 antipersonnel mine, and Claymore. The initial cue noted was generally the contrast of a device's color with its background, which then led to further investigation and generally a successful detection.

Devices detected most frequently by their shape were the 105mm artillery round and the DH-10 (VC Claymore). Although these devices were camouflaged, the trainees were apparently able to detect them by the characteristic shape of their exposed portions. A high rate of detection was noted for these devices (78.8%) as well as a sizeable average detection distance (14.5 feet).

An exposed triggering device was the cue noted most frequently for the tripwired hand grenade. The thin wire stretched across the trail at varying heights and angles had a high detection rate (77.5%), but a rather short average detection distance of 2.9 feet. The relatively high detection rate for the tripwires was probably due to a combination of factors: the fairly open areas in which they were employed, the more frequent use of this type of device, and the presence of most tripwires above the trainee's knees (there seemed to be more difficulty in detecting tripwires placed below the knees).

While not listed as the most frequent cue for any one device, device texture was second in importance overall. Trainees frequently explained their choice of the cue by saying they had noted the reflected light from an object, for example, sun on the exposed part of a Schumine or on a tripwire. This initial cue led to further investigation and, generally, a detection.

<u>Training Implication No. 4.</u> A training suggestion in this area would be to include instruction on basic cues (of the type just noted) that should be looked for during search. A detailed discussion of means of recognizing these cues should help an individual to interpret such signs as he moves through an operations area.

When there is a special situation, training emphasis should be placed on cues particularly appropriate to such an area. For example, if there was a noticeable difference between the color of the vegetation and the type of devices employed by the enemy, color would be the environmental variation stressed.

This emphasis on increased attention to the "how to look" aspect of detection is also supported by the previous HumRRO study by Maxey and Magner, where interviews with expert Vietnam-experienced detectors produced recommendations for improving training in mine and boobytrap detection. These experts felt that the present training emphasis on teaching individuals *what* to look for and *where* to look for it was important. However, many thought that more attention should be paid to instruction on *how* to look for these devices. It was suggested that this instruction be similar to visual tracker training, where the emphasis is on detecting and interpreting changes in the environment. The mine and boobytrap detector should look for environmental variations as initial indications of possible mine and boobytrap activity in the area. Follow-up searching can then determine whether there actually are devices in the area.

General Training Suggestions

The following general suggestions for improving visual mine and boobytrap detection training are based on current and past research in this area:

(1) Utilization of training time. In planning training for mine and boobytrap detection, the maximum amount of available training time should be devoted to practical field work. When time is limited, lecture or conference periods should be restricted to teaching the following topics: basic information about the type of devices likely to be encountered, where the enemy may employ these devices, and the procedures to use during search. However, trainees should always be given an opportunity to detect realistically concealed devices in a field situation, and required to use optimum movement rates during search.

(2) Types of enemy mines and boobytraps. Instruction on this topic should provide information on the basic mines and boobytraps employed by an anticipated enemy. Possible variations of these basic devices should be discussed. The emphasis of this instruction should be on means of detecting concealed devices, rather than on a detailed knowledge of the workings of the mines and boobytraps. Actual devices, working models, and/or reasonable replicas should be used when possible. Various fuzes and methods of activating these devices should be discussed, to provide additional detection information. Such information may serve to warn detectors of the types of danger to be anticipated when encountering devices actuated by different techniques—for example, tripwires, command detonation, pressure initiation. If it is anticipated that locally improvised mines and boobytraps may be encountered, examples of these devices should be discussed.

(3) Employment of mines and boobytraps. Instruction in this topic should provide information on basic tactics and techniques employed by an anticipated enemy in the past, as well as any known future employment plans and capabilities. This instruction should include (a) information about the locations in which the enemy most frequently employs mines and boobytraps, (b) tactical situations where their use may be expected, (c) the numbers and types normally employed under various conditions, (d) the enemy's skill in concealing devices, (e) techniques used to conceal them, (f) special mine warning systems used, and (g) methods of protecting mine fields. When training for detection in a specific operational area, this information should be tailored to anticipated operational conditions. Further, it should utilize all available intelligence on the enemy's recent mine and boobytrap activities.

(4) Preparation for field detection. A tactical walk through a prepared area is suggested as an appropriate type of training to prepare an individual to negotiate a field detection course. This can be accomplished by having an instructor guide a small group (5 to 8 men) through an area containing a number of mines and boobytraps concealed as they would be in an actual combat situation. The groups would be told to be alert for any cues indicative of the presence of concealed devices. Upon reaching the location of a concealed device, the instructor would point out and discuss the various cues that can assist in the detection of that particular device. The instructor also can designate point men on an alternating basis to stimulate interest as the group moves through the area. When a designated point man detects a device, he should point out and discuss the cues that helped him to find the device. The opportunity to see representative types of mines

and boobytraps realistically concealed and to discuss various detection cues should prepare trainees for the next phase of training, the field detection course.

(5) Negotiation of a field detection course. A field detection course is effective in providing a trainee with the opportunity to apply the detection knowledge gained during instruction. When possible, the course should be in a field environment similar to the area where future conflict is considered most likely. It should contain a variety of devices and employment techniques representative of the types discussed in earlier periods of instruction. The field course should be long enough to provide a reasonable distance between devices, to prevent detectors from anticipating concealed locations. The degree of detection difficulty should vary with the state of training. A course should become progressively difficult as trainees have additional opportunities to practice their skills. In order to increase motivation, the course should contain some devices that react when not detected—for example, a small explosion, whistle, or scattered liquid.

An instructor should go through the course behind a small group (2 to 4 men) to observe their performance. Each trainee should be given the responsibility of detecting concealed devices on various portions of the course. The instructor should note each trainee's successes and failures and briefly discuss the major detection cues that should have been recognized. After completing the course, a short critique should be held to discuss both good and bad detection techniques noted by the instructor. This type of training should be repeated, if time permits, using alternate detection lanes and varying conditions.

(6) Final field test. As a final evaluation of visual detection proficiency, trainees should be required to complete a field test course. A course similar to those used in previous detection training should be negotiated by individual trainees. An evaluator should accompany the detector to record the number of detections (both correct and false) made by the trainee. To encourage a maximum effort, rewards may be offered to trainees detecting the highest number of concealed devices. For example, winners may be given varying amounts of free time, letters of commendation, and similar rewards. Finally, depending upon the current manpower requirements, a minimum individual standard for successful detection performance should be set. Using this standard and the performance results from each stage of training, an assessment of each trainee should be completed to determine whether he is ready to apply his newly developed skills upon assignment to a tactical unit. If minimum standards are not met, partial or complete recycling of training should be implemented.

Chapter 4

DISCUSSION

IDENTIFICATION AND VALIDATION OF CANDIDATE INDIVIDUAL DIFFERENCES

A primary goal of the USAMERDC Human Mine Detector Research Program is to identify individual skills and aptitudes required for effective perceptual detection. In order to accomplish this goal, a list of design parameter categories was developed by the USAMERDC (see Table XVI). The objective of the *Task A* research was to identify specific variables for each design parameter category. In Table II, which summarizes the results of this research, specific individual difference variables are listed according to the appropriate design parameter category. Two other categories (Personal Characteristics and Acquired Knowledge) were added, to handle those differences which were found to be relevant but which were not covered by the USAMERDC categories.

The primary objective of the *Task B* research was to validate the candidate individual differences identified during *Task A* of Project *IDENTIFY*. The results of the validation showed that four of the 24 specific characteristics, aptitudes, acquired knowledges, and acquired skills were involved in the prediction of mine and boobytrap detection proficiency. These were (a) visual acuity, (b) speed of movement during search, (c) individual motivation (effort expended during search), and (d) dogmatism (level of dogmatism). In addition, it was found that the level of activities participation, the means by which a high school diploma was earned (graduation from high school or completion of the Tests of General Educational Development), and the number of years of civilian education completed were also related to detection proficiency.

Close inspection of the results also showed that speed of movement during search and individual motivation were the most important predictors of detection proficiency as this was defined in the present study. This result implies that individual differences specific to the field detection situation may play the most important role in influencing the level of detection proficiency an individual will manifest in the detection situation.

The impact of this conclusion for selection and training for mine and boobytrap detection is clear. First, it can be expected that the training procedures developed for detection are likely to be the most important factor influencing the level of detection proficiency an individual can attain. Second, because of the nature of the personal and physical characteristics that were associated with detection proficiency, it should not be very difficult to locate military personnel suitable for training in mine and boobytrap detection. Finally, highly proficient visual detectors can probably be developed through the implementation of training that stresses patience and instills the motivation to achieve at high levels in personnel who have at least graduated from high school and who are open-minded (scored low on the dogmatism scale).

RECOMMENDED SELECTION AND TRAINING PROCEDURES

An additional goal of the USAMERDC Human Mine Detector Research Program was to develop a valid test or tests for the selection of high aptitude trainees and to recommend appropriate mine detection training methods. The objective of the *Task C* research was to identify appropriate selection and training methods in support of the USAMERDC objectives. From the results of the validation, it was clear which individual difference variables were predictive of detection proficiency (see pages 24-28). Using this information, a selection test battery (see page 32) was recommended. It is believed that if the battery is used as described in Chapter 3, a high quality input to training programs designed to develop highly proficient detectors will accrue.

However, the results of the validation suggest that much or perhaps even most of the individual's eventual detection performance hinges on training considerations as opposed to innate abilities that could be uncovered by selection testing. Further, the present research suggests that training should emphasize factors influencing the conduct of the detection task substantially more, and perhaps de-emphasize the end products of the task. That is, training should much more strongly emphasize to trainees that they should move slowly, and that the more effort one puts into the task the more successful he will be. This should not *preempt* instruction on cues and types of devices by any means. Rather, the suggestion is that an *appropriate* emphasis should be given each aspect of training, *in view of the relative contribution* each aspect was felt to add to performance in the present research. Training recommendations developed by the project IDENTIFY staff reflect this philosophy.

To aid in the implementation of these recommendations, general suggestions for the conduct of training are offered. It is expected that, if these recommendations and suggestions are implemented, high quality detectors can be trained to meet unit requirements in future combat situations.

HUMAN FACTORS DATA ANALYSIS

False Detections

Less than 2% of the Course I detections were false, while just over 22% of the Course II and III detections were false. One possible explanation for this result is that Course I detection cues may have been more valid indicators of the presence of a device than were Course II or III detection cues. Under these conditions, it would be expected that on Course I false detections would not occur very frequently. However, on Courses II and III false detections would be expected frequently.

Another possibility is that the criteria for making a detection were less stringently applied on Courses II and III than on Course I. It would follow that as the criteria for making a detection were relaxed, more false detections would be likely to occur. As a consequence, the frequency of false detections on Courses II and III would be larger relative to Course I.

Detection Proficiency and Accuracy

The average detection rate was highest for the road course, next highest for the wooded course, and lowest for the open country course. The accuracy of response was highest for the wooded course, next highest for the open country course, and lowest for the road course.

These results would appear to indicate that visual detection in a wooded area similar to the type studied in this research should provide both an accurate and a proficient means of countering the mine and boobytrap threat. For open fields, under similar conditions, a lower accuracy and proficiency rate might be anticipated compared to the wooded area. Finally, for road areas similar to the one used in this study, a comparable detection rate and a lower degree of accuracy might be expected compared to the wooded area.

Effect of Device Size and Employment on Detection

The results of the ease of detection data analyses revealed that the size of a mine or boobytrap device had a definite effect on its detectability. This seems to be a rather simple effect, with larger objects being more easily detected, perhaps because they are harder to hide. For example, DH-10s were more detectable than hand grenade boobytraps. It was also clear that whether a device is employed above or below ground will affect its detectability. Small devices buried in the ground, such as M16 or M25 Antipersonnel Mines, were harder to detect than small devices employed above ground, such as hand grenade boobytraps. These results suggest that the optimal mine or boobytrap device should be very small and be buried in the ground. Low rates of detection for these devices can be expected.

The results of the analyses of estimated detection distances tended to agree with the results of the detectability analyses. Devices that were detected more frequently also tended to be detected farther away than devices detected less frequently. Thus, it would appear that size was a major factor influencing the detectability of mines and boobytrap devices employed in the present study.

Relationship of Findings to Prior Research. The results of the current research tend to agree with the findings for the detection of surface laid munitions.[1] In both types of detection situations, some individuals are very "good" at finding devices that are not readily visible to the human eye, while others are not. Further, in both situations, general ability is significantly related to detection performance (to the extent that GT test performance and number of years of civilian education reflect general ability). Finally, in both situations search time is related to detection performance since, for a fixed-length course, search time is the inverse of search speed. The implication of these results is that the skills employed during the detection of surface laid munitions and mines and boobytraps are probably highly similar.

The current findings also support prior HumRRO research in this area.[2] Analysis of data gathered on 21 individual difference variables yielded only two significant relationships between detection expertise and these variables. In the present study, correlational analysis (see Appendix A) yielded only three significant relationships ($p < .01$) between detection performance and the 27 variables assessed in the study (speed of movement during search, effort expended in search and number of years of civilian education, $r = .62, .57$, and $.28$). The current results thus continue to suggest that human mine detection is essentially an unidimensional ability that is related to only a small number of specific individual parameters. The implication of these findings is that future research in this area should be oriented toward refining the measurement of the individual differences known to be related to detection performance.

[1] Carlock, J. and Buckfin, B. "Human Factors in Mine Warfare: An Overview of Visual Detection and Stress," paper prepared for presentation at the TTCP Panel 0-1 Working Group 8, Mine Warfare Study Group Seminar, October 1971.

[2] Maxey, J.L. and Magner, G. J. *A Study of Factors Affecting Mine and Boobytrap Detection: Subject Variables and Operational Considerations*, HumRRO Technical Report 73-12, June 1973.

CONCLUSIONS

This report presents the results of research conducted to identify and validate a set of individual difference variables predictive of human mine detection performance. In addition, it discusses personnel selection and training methods for human mine and boobytrap detection identified by the staff of Project IDENTIFY from assessment of the results of the validation.

To accomplish this research, the following systems-analytic steps were implemented. First, the potential characteristics, aptitudes, and acquired skills involved in the detection of mines and boobytraps were identified by:

(1) Development of a job model that identified inputs into the personnel who perform the detection job and outputs that may go back into the job environment.

(2) Development of a psychological analysis in order to determine the specific human cognitive and perceptual aptitudes that are likely to be involved.

(3) A review of psychological literature to identify individual differences that have been shown to be related to visual discrimination.

From this research, several candidate variables were identified, and related to the following design parameter categories: physical characteristics, mental characteristics, personal characteristics, personality characteristics, native aptitudes, acquired skill, and acquired knowledge.

To test the theoretical relationship between these variables and actual detection performance, a validation that tested 17 variables which were judged amenable to practical assessment was conducted. Fourteen of these variables were measured by pencil-and-paper test instruments, while three of the variables were felt to be best measured during the conduct of a field detection proficiency test. One hundred and eleven Infantry AIT graduates from the 197th Infantry Brigade at Fort Benning, Georgia, participated in the validation and the results of the study were assessed by statistical analyses.

From the validation of the candidate predictor variables, it was found that speed of movement during search and the effort that appeared to be expended during search were the primary predictors of mine and boobytrap detection performance as it was defined in this study. Other variables identified by the validation analysis as important predictors were: visual acuity, level of activities participation,[1] means by which a high-school diploma was earned (by graduation or by completion of the Tests of General Educational Development), number of years of civilian education completed, and level of dogmatism.[2] Based on these results, it is clear that individual differences exist that are predictive of detection performance in field situations.

In addition to the results of the selection validation, a large quantity of human factors data involving the visual detection of mines and boobytraps was collected. It was found that larger devices that were placed above ground were detected more often than smaller devices that were either completely or partially buried. Also, exact detection rate information was developed for a specific type of anti-personnel and anti-tank mines. This

[1] HumRRO Activities Inventory, Part I.
[2] Rokeach's (1960) Dogmatism Scale.

information is, of course, quite useful to personnel involved in the development of mine and boobytrap type devices.

As a final step in Project IDENTIFY, HumRRO research and technical personnel assessed the results of the validation and developed recommendations for appropriate personnel selection and training methods. A selection test battery for detection proficiency was recommended, to consist of two paper-and-pencil tests (an inventory of activities participation, and a test measuring level of dogmatism) a visual acuity performance test, performance tests measuring speed of movement and the effort an individual appears to expend during an outdoor search task (not mine and boobytrap specific), and an information form that collects the candidate's identifier, the number of years of civilian schooling completed, and whether or not the candidate has received a high-school diploma and, if so, how it was obtained.

Finally, there was a discussion of how the results of the battery should be used to select personnel for entrance into training for mine and boobytrap detection. Several of the more salient training recommendations were:

(1) Stress the requirement to move slowly and carefully, in an area suspected of containing mines or boobytraps.
(2) Emphasize the importance of motivation to achieving detection proficiency.
(3) Include the area search/footfall procedure in training detectors.
(4) Include instruction in basic cues to be looked for during search.
(5) Devote maximum available training time to practical field work.
(6) Provide information on the basic mines and boobytraps employed by an anticipated enemy.
(7) Provide information on basic employment tactics and techniques used by an anticipated enemy.
(8) A tactical walk through a mined area should precede negotiation of a field detection course.
(9) A field detection course is recommended as an effective way of providing a trainee with the opportunity to apply the detection knowledge gained during instruction and of evaluating his proficiency prior to, during, and after the completion of instruction.

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Appendix A

INTERCORRELATIONS OF PREDICTOR AND CRITERION VARIABLES

	AGE	HEIGHT	WEIGHT	EDUCATION	VISUAL	SMOKING	IOO	MA	TTMO	KMBT	KMF	KDM	TKS	EFTS	IETS	IOTS	AVFREQ	CIS	DIS	CIDIS	SIS	CTIME	RACE	EFFORT	SEARCH	TOTALDET	NOHS	GED
Age	--																											
Height	.00	--																										
Weight	.09	.53	--																									
Civilian Education Completed	.23	-.02	.03	--																								
Visual Acuity	-.18	-.04	-.01	-.04	--																							
Years of Smoking	.08	.04	-.02	-.25	.01	--																						
Dogmatism (Opinions)	.07	-.18	-.04	-.09	.24	.20	--																					
Manifest Anxiety	.04	.07	.02	.04	.17	-.01	-.17	--																				
Team Orientation (Motivation)	.22	.05	.12	.07	-.16	-.01	-.04	-.17	--																			
Knowledge of Mines and Boobytraps	-.14	-.04	.09	-.11	-.01	.08	.01	-.17	-.34	--																		
Knowledge of Mine Fields	.05	.15	-.04	.01	-.12	-.09	-.01	-.16	.01	.24	--																	
Knowledge of Detection Means	-.01	.07	.02	-.02	-.03	.05	-.02	.04	.08	.33	.13	--																
Total Knowledge	-.06	.07	.04	-.07	-.08	.02	-.00	-.18	-.30	.83	.70	.51	--															
Embedded Figures	-.06	.06	-.11	-.01	.06	.10	-.10	-.24	.10	.19	.07	.13	.19	--														
Information Extraction	-.07	-.01	-.12	.04	.09	-.02	-.21	[illegible]	.06	.20	.17	.39	.30	.37	--													
Incomplete Objects	.02	.10	.00	.04	.02	.03	-.10	-.21	.03	.14	.31	.08	.27	.25	.28	--												
Frequency of Activities	-.05	.05	.02	-.08	.01	.13	.08	-.09	.12	.19	.12	.15	.22	.28	.22	.22	--											
Background Confidence	-.07	.13	.10	-.09	.04	.17	.02	-.27	.16	.18	.18	.26	.27	.27	.25	.24	.78	--										
Background Despair	.08	.19	.01	-.10	-.00	.20	.15	.03	.21	-.03	.15	.12	.09	.22	.12	.10	.34	.63	--									
Stress I	-.16	.02	.11	-.06	.07	.07	-.09	-.41	.05	.26	.11	.23	.27	.17	.22	.22	.51	.78	.03	--								
Stress II	-.16	.02	.11	-.02	.06	.05	-.11	-.42	-.00	.28	.10	.26	.28	.10	.16	.17	.29	.56	-.24	.90	--							
Course I Search Time	-.02	.00	-.06	.11	.07	-.02	-.02	-.13	-.01	.19	-.01	.10	.14	.22	.10	-.06	-.04	.07	-.07	.15	.14	--						
Race	.09	.13	.06	.32	.05	-.10	.02	.18	-.08	-.30	-.10	-.26	-.30	-.35	-.43	-.15	-.37	-.34	-.15	-.30	-.26	.02	--					
Effort Expended in Search	.04	.05	-.05	.10	.05	-.06	-.05	-.15	.07	.18	.05	.06	.15	.12	.16	.06	.09	.16	.07	.15	.07	.48	.30	--				
Search Technique	.04	.12	.15	.01	.04	-.06	-.07	.10	.04	.02	.06	.06	.06	-.18	.08	.17	-.07	.00	-.11	.08	.15	.03	-.04	-.01	--			
Total Objects Detected	.02	.10	-.01	.28	-.07	-.04	-.14	-.14	.12	.12	.12	.11	.11	.16	.11	.04	.14	.19	.09	.17	.12	.62	.05	.67	-.13	--		
High School Graduation	.20	.01	.05	.62	-.13	-.24	-.14	.11	.06	-.10	.10	.07	.01	-.01	.23	.05	-.02	-.04	-.08	-.00	.02	.08	.16	.03	.11	.22	--	
GED Tests Completed	.01	.07	.10	-.15	-.01	.01	-.07	.07	-.06	.05	.19	.16	.17	.13	.20	.01	.14	.22	.12	.19	.18	.00	-.22	-.07	.12	-.08	.37	--